DR. J. LEON WILLIAMS, OF LONDON, IN HIS OFFICE.

Fig. 3.

SECTION OF ROOT OF FORMING TOOTH. × 150.

a and a^1.—Blood vessel in pulp of root.

b.—Pericementum.

d and d^1.—End of root of tooth.

f.—Blood vessel entering end of root from pericementum.

e.—Bundle of non-medullated nerve fibres entering root from pericementum.

c.—Bundle of non-medullated nerve fibre showing two fibrils given off to blood vessel.

Fig. 4.

SECTION THROUGH LOWER JAW OF *BETTONGIA LESUEURI* SHOWING END OF ROOT OF FORMING TOOTH AND MEDULLARY SPACE OR CANAL. × 75.

a.—Blood vessels in pulp at end of root of tooth.

b and *f*.—End of root.

c.—Bundle of non-medullated nerve fibres.

d.—Blood vessel entering from medullary canal and giving off branches to pulp and pericementum.

Fig. 5.

SECTION THROUGH JAW OF *BETTONGIA LESUEURI* SHOWING ROOT OF TOOTH AND PERICEMENTUM FROM NECK OF TOOTH DOWNWARD. × 75.

a and a^1.—Blood vessels in transverse section.

b.—Bundle of non-medullated nerve fibres.

c.—Pericementum.

d.—Dentine of root of tooth.

e.—Pulp in root.

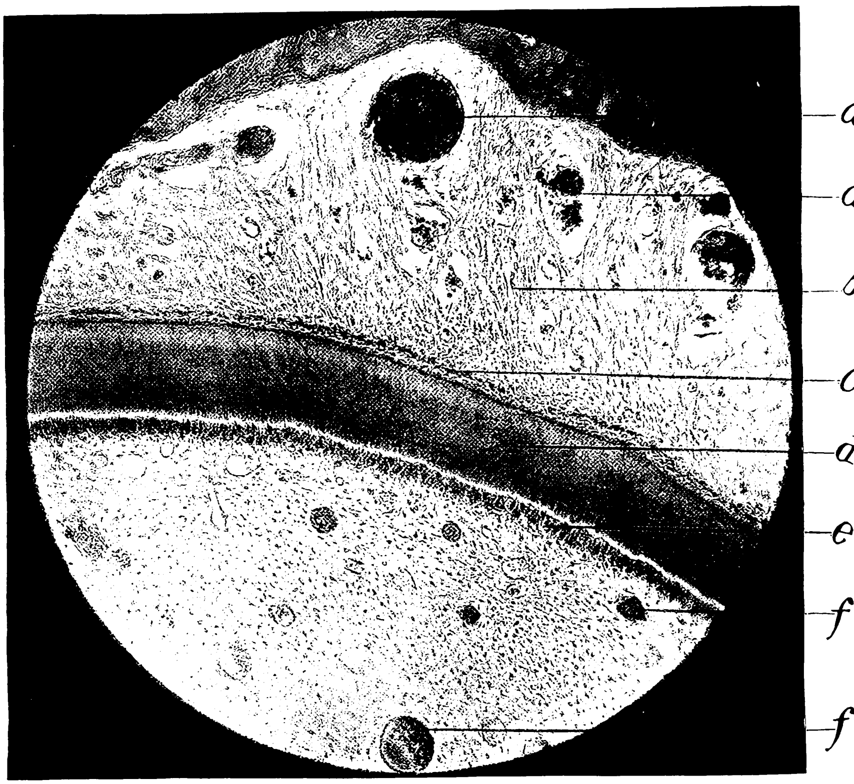


Fig. 6.

TRANSVERSE SECTION THROUGH PERICEMENTUM, DENTINE OF ROOT AND PULP. $\times$ 75.

a and *a*¹.—Blood vessels in transverse section with corpuscles *in situ*.

b.—Pericementum.

c.—Showing formation of cementum.

d.—Dentine.

e.—Odontoblasts.

f and *f*¹.—Blood vessels in pulp.

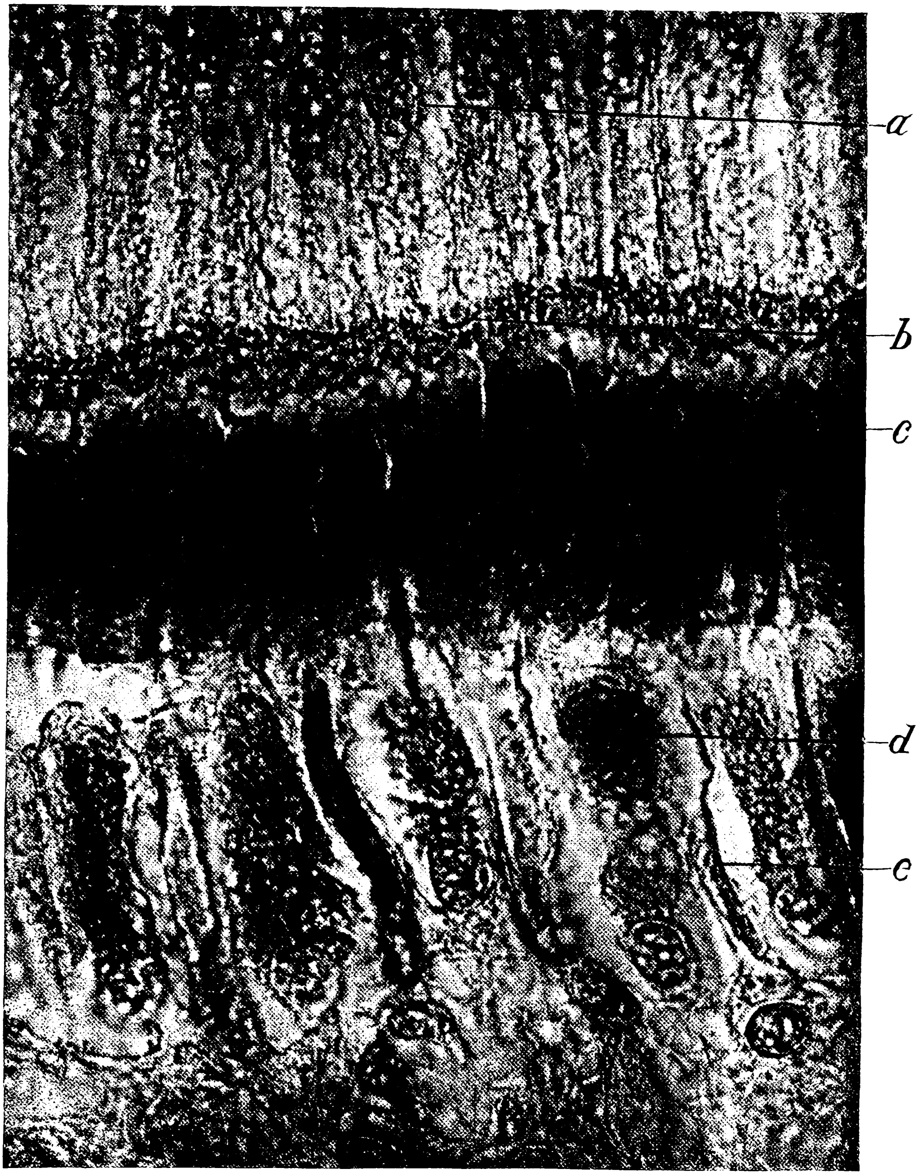


Fig. 7.

SECTION THROUGH DEVELOPING TOOTH OF BOVINE EMBRYO. × 2,000.

a.—Ameloblasts, showing large, oval nuclei.
b.—Commencement of enamel formation.
c.—Dentine.
d.—Odontoblasts.
e.—Processes from which dentinal fibrillæ arise passing between odontoblasts.

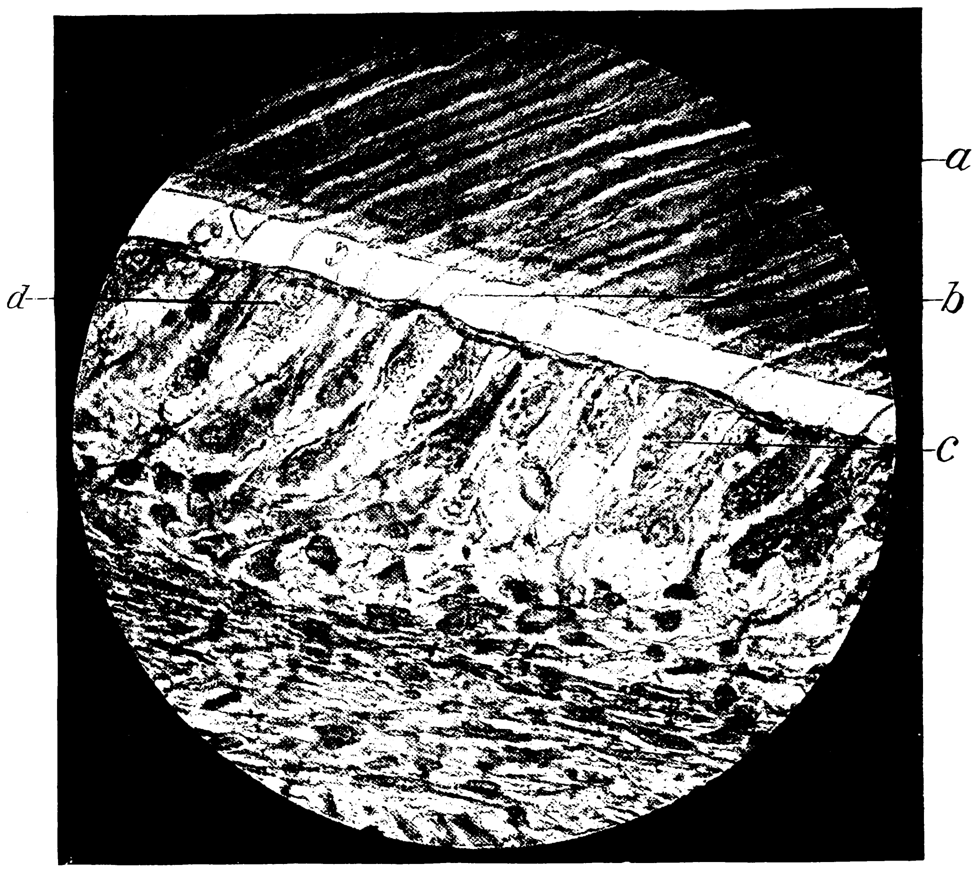


Fig. 8.

SECTION THROUGH DEVELOPING TOOTH. × 1,200.

a.—Dentine.

b.—Dentinal fibre, given off from odontoblast, containing granular contents apparently identical with cytoplasm of odontoblast.

c.—Odontoblasts.

d.—Odontoblasts showing nuclei at end of cells nearest to forming dentine.

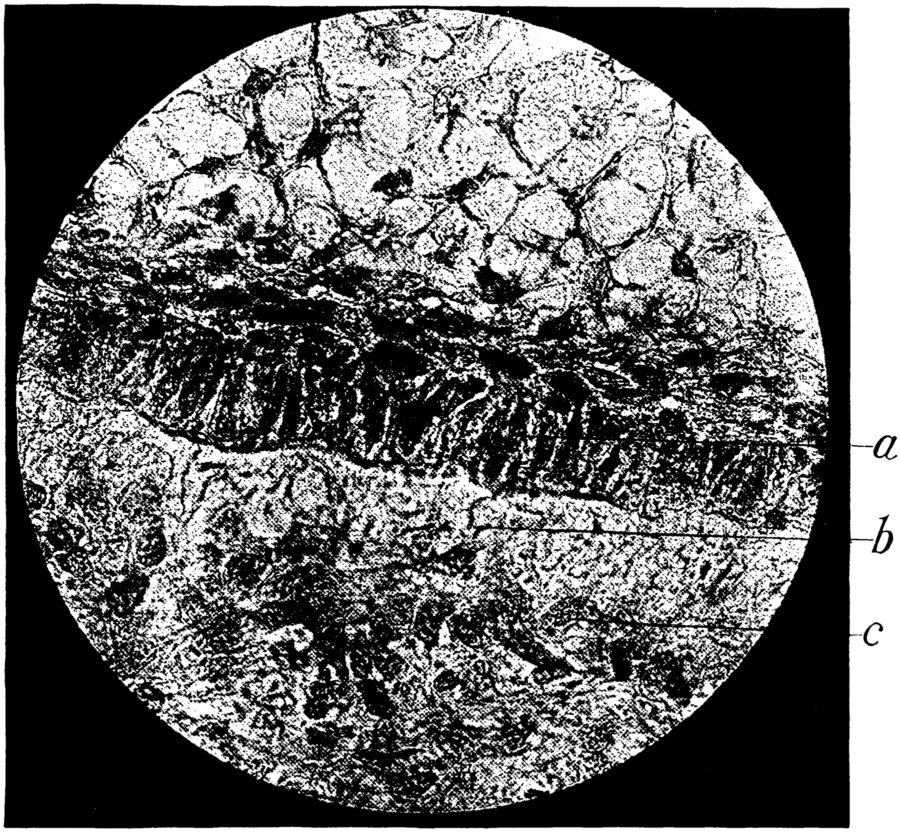


Fig. 9.

SECTION OF DEVELOPING TOOTH OF BOVINE EMBRYO. × 600.

a.—Ameloblasts.
b.—Commencement of dentine formation showing development of fibres apparently not attached to odonotoblasts.
c.—Developing odontoblasts.

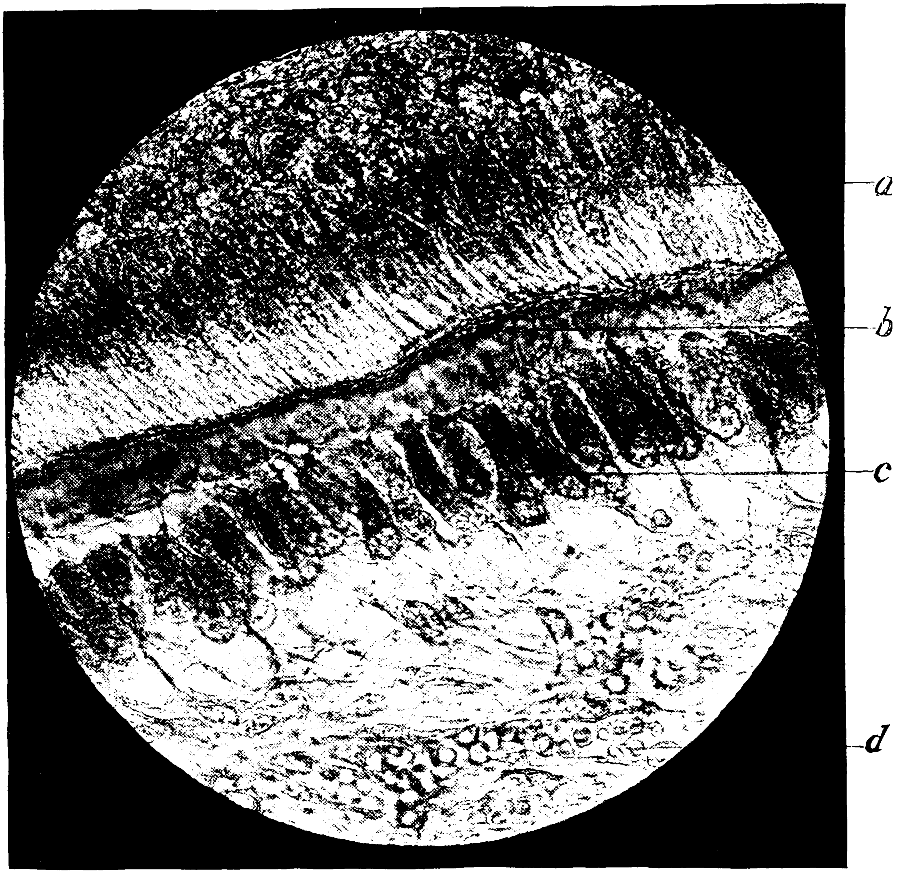


Fig. 10.

SECTION THROUGH DEVELOPING TOOTH. × 600.

a.—Ameloblasts.
b.—Dentine.
c.—Odontoblasts.
e.—Blood vessels.

Fig. 11.

SECTION THROUGH DEVELOPING TOOTH. × 600.

a.—Ameloblasts.
b.—Showing commencement of formation of dentine.
c.—Odontoblasts with fibres extending from pulp ends

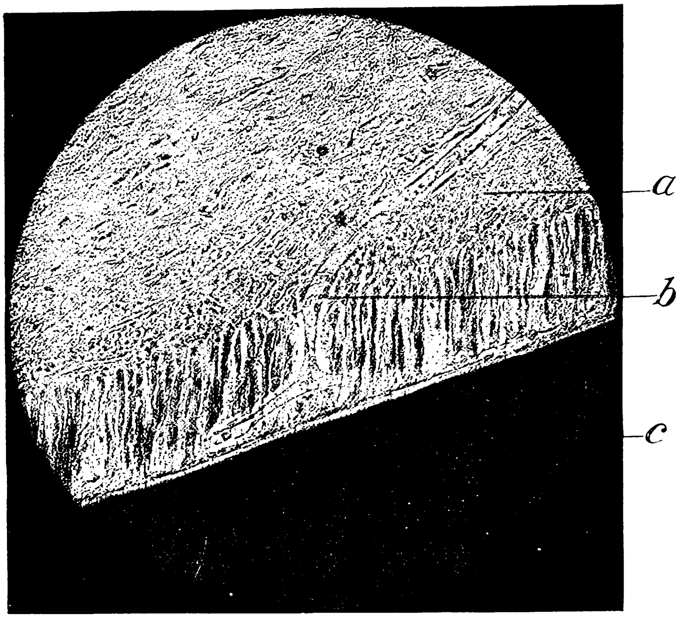


Fig. 12.

SECTION THROUGH PULP AND ROOT.

a.—Pulp.
b.—Blood vessel entering odontoblast layer of cells from pulp.
c.—Dentine.

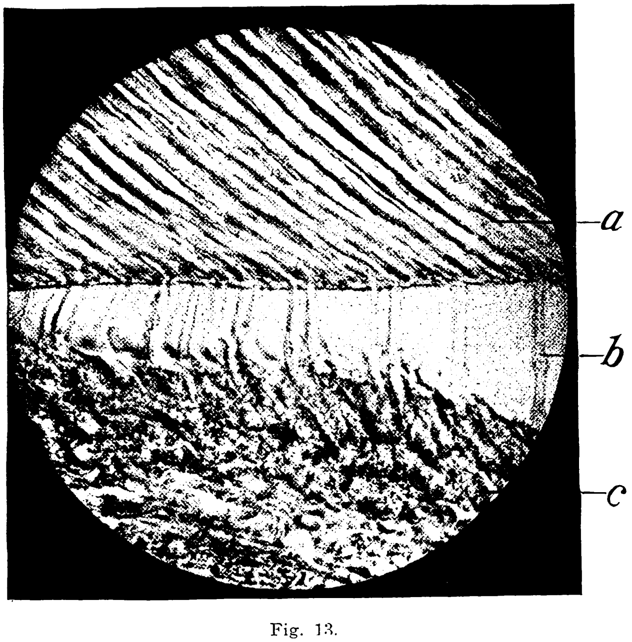


Fig. 13.

SECTION OF DEVELOPING TOOTH OF EMBRYO LAMB. × 350.

a.—Dentine.
c.—Pulp pulled away from dentine to show structure of dentinal fibres at b.

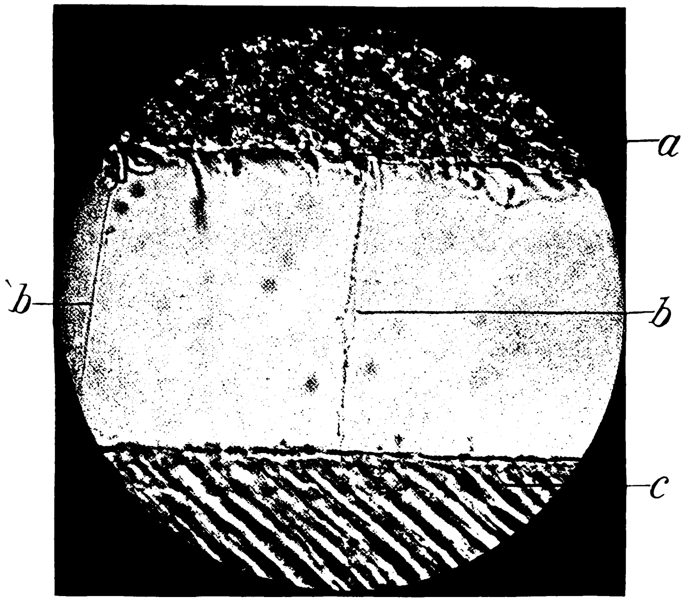


Fig. 14.

FROM DEVELOPING TOOTH OF EMB RYO LAMB. × 800.

a.—Pulp.
c.—Dentine.
b and b^1.—Dentinal fibres of different appearance and structure.

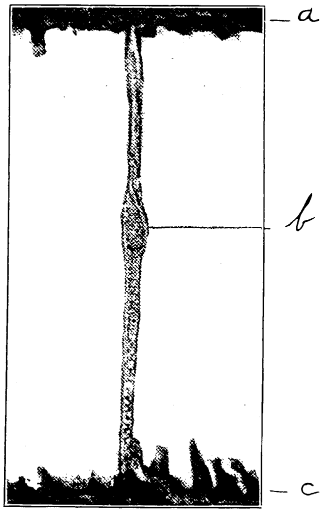


Fig. 15.

FROM DEVELOPING TOOTH OF EMBRYO LAMB. × 1,200.

Dentinal fibre very highly magnified.

a.—Edge of dentine
c.—Edge of pulp.
b.—Oval enlargement of fibre resembling structure of nerve fibres.

EXCLUSIVE CONTRIBUTIONS

An Illustrated Interview with Dr. J. Leon Williams, of London.

Sham Ethics.

An illustrated interview by mail? Yes, I have no objection to it, providing you wish to talk about matters of general interest to the profession. I say this because your first question as to my personal surroundings should be cautiously answered, especially in view of your recent attitude on the subject of ethics. What an amount of humbug has accumulated about this subject of professional ethics. I suppose we must have some rules of conduct. Legislation also we must undoubtedly have. At the same time it needs no very extensive acquaintance in the world to discover that neither rules nor laws can be made to force men into true ethical conduct. The best that can be accomplished by such means is, after all, but a mere sham of real ethics, an outside veneer that is often so thin as to be quite transparent. If a man does not believe that it is best to maintain an ethical attitude toward his fellows, none of your nets or traps will catch him. What you do catch is the chap who openly defies you and he is often an honorable man when compared with that individual who is always shouting at the top of his voice for a rigid code of ethics, the while he artfully contrives by the most insidiously selfish methods to secure and maintain a position of advantage over his colleagues. But that's another story, as Kipling would say, and I must keep to the sufficiently fat text which you have supplied in your question.

Artistic Environment for Dentists.

First, then, as to my surroundings. It matters very little what my personal surroundings may be, but it matters very much, in my opinion, what the surroundings of a dentist are. As a believer in the doctrine of evolution I must consider environment as a matter of great importance. I most cordially reject the recently expressed views of one who believes that the dentist's environment should be four bare walls, a bare floor, an operating chair and a surgeon's apron—all of this, I suppose for the moral effect upon the ubiquitous bacteria. Let us not be entirely thrown off our balance by the sight of

a micro-organism. Let us, at least, remember that the phagocytes are always on guard and that there is, consequently, always room for hope.

A dentist's life is practically spent in his operating room. He should therefore make it as pleasant and cheerful a place as all the circumstances will permit. There are also other and purely utilitarian reasons why this should be done. Dentistry is an art. True, it is founded, or is supposed to be founded, upon scientific principles, but in its practical application it is very largely dominated by art ideas. Now, while the principles of an art can be taught and learned, history shows that the *initiative impulse* which has produced all the best art work of the world is a something outside or apart from anything that can be taught or learned by the ordinary intellectual methods. The silent, slow, but cumulative power of environment, acting largely through the subconscious mind, contributes vastly more than has generally been suspected towards the *impulse* that produces great art work. Nuremburg was the environment that produced Albrecht Dürer; the dramatic and epoch-making Elizabethan age supplied the environment that produced Shakespeare; and every human being is what he is by virtue of his environment, plus ancestral endowment. A man can no more get away from the effects of his environment than he can escape from the law of gravitation. The one is as real as the other. This does not mean that all men are influenced equally or in the same way by their environment, but it does mean that all other things being equal, the man who has the best environment will produce the best work. And the more sensitive a man is, in other words, the more highly he is endowed with capacities for the reception of stimuli and powers of reaction from these stimuli, the more important it becomes for him to study his environment. A dentist's work is, or should be, largely of an artistic nature. It is the direct product of his mind and hand. He should therefore surround himself, so far as is possible, with an environment which tends to foster and cultivate his sense of the esthetic, not alone for the powerful direct effect of his surroundings upon his work (this is probably the less important influence), but because the constant effect of his surroundings upon his subconscious mind is like the accumulation of force in a storage battery. And it is from this reserve force, so to say, that the impulses for most of our actions proceed. This is not sentiment, but the newest science. The latest researches in psychology make it, at least, extremely probable that no impression made upon any of the senses is ever lost, whether or not that impression rises into the conscious region of the mind at the time. These impressions are all stored in the vast regions of subconsciousness, out of which the force of our impulses to action arise, and the quality of our action is often largely governed by the nature of the raw material in the shape

of impressions stored in this reservoir. The cultivation of the esthetic sense therefore is an investment in the most precious of raw materials for our life work.

Mahomet said: "He that hath two cakes of bread, let him sell one of them and buy some flower of the narcisse; for bread is the food of the body, but narcisse is food for the soul."

The price of a case of champagne will pay for a work of art, and a genuine work of art may become a silent educator through all one's life. A paraphrase of Polonius's advice to Laertes will sum up my views on this point:

"Artistic thy environment as thy purse can buy, . . . For the surroundings oft proclaim the man."

Question 2. "Have you any special methods of operating, a description of which would be of interest to the profession?"

Answer. I have no unique method of operating so far as I know. For several years I have noticed a tendency to use fewer instruments. In other words, a tendency towards simplicity and directness in methods of operating. In the preparation of cavities, and especially in the opening up of cavities which involve the treatment of pulp canals, I cut much more freely than formerly. I do not like attempting to shoot around corners or to chase bacteria up blind alleys. I want to see just what I am doing, and this leads me to speak of an instrument which I really ought to have described before. Several years ago it occurred to me that the instruments for opening pulp canals were about as badly devised for their work as they could be. They are expensive, inefficient when new, and rapidly worn out—when not broken off in pulp canals. My cogitation on the subject resulted in the instrument shown in Fig. 1. It is, as you see, a modification of the three-sided reamer, but the modification is much the most important feature of the tool. Each of the three sides is deeply grooved. The result of this grooving is twofold. It makes an instrument which is as easily sharpened as an excavator, and which can, therefore, be kept in the finest cutting condition until worn out. (As to their durability, I can say that I am still using instruments which were made for me three years ago.) The grooves also render the tool self-clearing. It never clogs, it cuts very rapidly, and there is not the slightest danger of forcing it through the side or end of the root. It leaves roots which have a curvature at the end in the best possible condition for treatment with sulphuric acid or by any other method, i. e., with a large cone-shaped opening giving an abundance of room

FIG. 1.

for working and seeing. It cuts away more of the infected dentine with less destruction of the root than can be accomplished by the use of any other instrument. And, finally, it leaves the root canal exactly the shape required for the strongest and best form of pin for crown work—a pin which is largest and strongest where it joins the crown and which gradually tapers to a fine point in the end of the root. Crowns with a pin of this shape are much less liable to get loose because the pin can be made much longer. Also, one never finds an air cushion beneath a pin of this shape when cementing a crown in place. From every point of view, therefore, I regard this as much the most valuable instrument for opening pulp canals that I have ever used. While upon the subject of pulp canals I may as well make my contribution to the extensive literature which has grown up around this theme.

Root Canal Treatment.

In cases where crowns are not to be set, my usual method of procedure is as follows: Open up canal with the instrument above described, which, in most instances, can be done in about thirty seconds. Flood the canal with peroxide of hydrogen or etherial solution of pyrozone. Let this remain for one minute or, if bubbles are given off, until they cease. Dry, and flood with absolute alcohol. Leave this for thirty seconds, and then dry again, this time very thoroughly, with some form of root canal dryer. Then swab out with the following:

Canada balsam dissolved in spirits of turpentine, to which is added ten per cent. of a saturated solution of hydronaphthol in chloroform.

Leave the canal flooded with this and insert a gutta-percha cone large enough to fill the canal and force it firmly to place. The absolute alcohol absorbs the moisture from the dentine very rapidly, and this, with the action of the heated root dryer leaves the dentine in a condition in which the balsam will penetrate to a considerable depth. The forcing home of the gutta-percha cone also tends to assist this action. This in my hands has proved to be the most simple and satisfactory method of treating pulp canals, and the enire operation does not require much more time than I have taken to describe it. Of course, if there is any complication outside the end of the root, ordinary methods of treatment for such cases must be adopted.

Question 3.

"Should any portion of dentine that has been softened by the action of bacterial acids be left in a cavity prepared for filling?"

Answer.

This is a question that can hardly be answered offhand, or without the use of several ifs and buts. *If* there has been no inflammation or but slight inflammation of the pulp I think it is perfectly safe to leave a layer of par-

tially softened dentine over the pulp *providing the proper treatment of this softened dentine has been carried out.* And this is my idea of the proper treatment in such cases.

Treatment of Softened Dentine.

Remove the softer portions of dentine and place a pledget of cotton wool saturated with absolute alcohol in the cavity. Leave this for one minute, then remove, dry the cavity, and flood it with oil of cloves which also leave for one minute. Any one accustomed to histological work will see the *rationale* of this treatment at a glance. Oil of clove is known to the histologist as one of the most powerful *clearing* agents known, i. e., it has the property of very rapidly penetrating any tissue, even bone and dentine, that has previously been treated with strong alcohol. It is a sufficiently good germicide for the purpose and it seems also to have a medicinal effect of value in slight congestion of the pulp. Used as above described, it will penetrate a considerable thickness of dentine and thus search out and destroy or render inert any forms of bacteria that may have penetrated beyond the point where you have cut. Dry out the excess of oil of cloves and varnish the bottom of the cavity with Canada balsam dissolved in chloroform to which has been added ten per cent. of the solution of hydronaphthol in chloroform previously spoken of. For this use, the balsam is dissolved in chloroform instead of turpentine, because here we wish it to dry rapidly, while in the treatment of the root canal we do not wish it to dry rapidly. Partially dry the layer of varnish in the bottom of the cavity with hot air and then apply to the floor of the cavity a piece of thick asbestos paper cut the proper size and shape. The partially dried varnish will hold the asbestos paper firmly in place. Now line the cavity with quick setting Dirigo antiseptic cement and fill with gold or amalgam. Such treatment will leave the tooth reasonably free from sensitiveness to thermal change even when the pulp is nearly exposed.

You have expressed the opinion that in the preparation of cavities for filling, the danger lies in cutting too little rather than too much. If you will allow me to confine your statement to the outer parts of the cavity then I am in most complete agreement with you. I am convinced that nine-tenths of all the failures in filling teeth arise from two causes or conditions which are closely related. First, insufficient cutting and polishing of the enamel margins of cavities; and second, insufficient care in the finishing and polishing of fillings. As announced in my last article in the *Cosmos*, I am now working at a paper on the subject of "hard" and "soft" teeth, and one feature of this will be the demonstration of the extensive softening of enamel due to bacterial action, which often occurs long before there is any breaking down of tissue from the

ordinary clinical point of view. Now, in many cavities, especially those on proximal surfaces, this softening of enamel extends much beyond the point where cutting usually ceases. Probably the most treacherous point in a cavity, and the one most frequently overlooked, is the region where the enamel joins the dentine. Very free cutting of enamel margins and the most perfect polishing should be insisted on. As to the *shapes* of cavity margins, one cannot do better than to follow the instruction of your own excellent work and also the articles by Dr. Black on this subject.

Treatment of Enamel Margins.

None of the instruments supplied for polishing cavity margins have proved satisfactory to me. The corundum and stone points made for this purpose are much too large. If they could be made small enough they would wear out so rapidly as to make them almost impracticable. I have therefore had made for me by Messrs. C. Ash & Son, a set of instruments especially designed for polishing enamel margins. They are made of soft iron and are charged with diamond dust. As they must be used wet, the cavity margins must be prepared before the dam is adjusted, a course which I always prefer for two reasons. It permits a free use of the warm water syringe for washing away débris, and it greatly facilitates the adjustment of the dam by the removal of all sharp and jagged edges. These instruments are shown in natural shapes and sizes in Fig. 2.

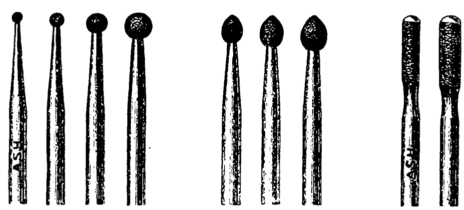


FIG. 2.

I have no doubt a soft iron instrument used with fine corundum or carborundum powder would be just as efficient, and these tools may be so used when the diamond dust is worn away. In use, these instruments should always revolve from the interior of the cavity outward, in the direction in which they are cutting, then towards the right on one side of the cavity, and, by reversing the engine, towards the left on the other side. By using them in this manner the most perfect enamel margins will be secured. And this leads me to remark that the present custom of using burs which cut in one direction only is altogether a mistake. Of course, a few cavities can be entirely prepared as well with a tool revolving only in one direction, but a great majority cannot. With the splendid electric engine now made which can be instantaneously

reversed and which runs as well in one direction as in the other, there is really no excuse for not demanding burs which cut in both directions, i. e., a dentist's outfit of burs should be composed of two kinds, one cutting from right to left and the other cutting from left to right. A bur, in whatever position it is placed, should always cut from within the cavity outward in the direction in which it is revolving. So used, it is much less painful to the patient and its work is much more rapid and efficient.

Nerve and Blood Supply of the Dental Pulp.

By Dr. J. Leon Williams.

Question 4. "What is the nerve and blood supply of the dental pulp? Does the nerve pass as a main fibre from the trunk nerve directly through the foramen, or are the nerves in the pulp continuations of the nerves in the pericementum?"

(Comment by Dr. Ottolengui on the above question.)

"In relation to this question I would call your attention to the fact that, in all illustrations in the text books, nerves are depicted passing out through the foramina, finally reaching the inferior or superior dental nerve. I mention the inferior dental nerve first because lying in a large channel directly under the roots, it is a plausible theory that branches should extend beyond into the ends of the teeth, but there is no analogous channel in the upper jaw. Sections which I have made did not find any such condition of affairs—moreover, if the nerves extended through the foramina, it would seem certain that in some extracted teeth the ruptured nerve would appear extending beyond the end of the root, which is never the case. My belief is that the plexus of nerves in the pulp are continuations of the nerves in the pericementum. Some very important clinical facts depend upon your reply, and it would seem of great benefit to determine this question finally and authoritatively."

Answer. While disclaiming all intention of posing as an "authority," a function I always hold more or less in suspicion, I gladly give you such information as is in my possession. Let me say at once, then, that so far as the clinical aspect of your question is concerned, your conjecture is perfectly correct. There is a direct *vaso-motor* nerve relationship between the pulp and the pericementum. I have been over the literature of the subject somewhat

carefully, and I can find only one indirect reference to this point and that, as one might have expected, comes from Dr. Black. But his attention seems to have been fixed upon other matters at the time and he gives us no direct information. But the fact of this nerve relationship is most clearly and unmistakably shown in Fig. 3. Here a nerve trunk, composed of, perhaps, twenty-five or thirty fibrils is seen passing directly from the pericementum into the open end of the root of a young tooth, the apical portion of which is not yet quite completely formed. The trunk disappears in the substance of the pulp and a short distance above this point four or five fibrils reappear, two of which are seen to branch off to a neighboring blood vessel.

That this nerve does not enter from the medullary canal is still more plainly seen in Fig. 4. Here we see a foramen in the bony partitions separating the tooth socket from the medullary canal and through this opening a blood vessel passes and divides in the cavity of the tooth socket, one branch passing toward the opening in the end of the root and the other toward the pericementum. But the bundle of nerve fibres is seen to pass directly by the foramen toward the percimentum. In Fig. 5 we see at b a bundle of nerve fibres high up on the side of the tooth socket just where the pericementum passes into the fibrous, sub-mucous tissue of the gum. We have thus traced these non-medullated nerve fibres from the pulp into the percimentum and to a point near the entrance of the tooth socket.

This suggests several questions of importance, the foremost of which is: Are there two sets of nerve fibres distributed in the dental pulp and percimentum?* There is no doubt about the distribution of nerve fibres from the inferior and superior dental nerves direct to the pulp of the teeth. Are these entirely fibres of special sense distributed to the odontoblast? And if so, from what source arise the vaso-motor fibres? Are the bundles of fibres which arise from the dental nerves *all* medullated fibres, becoming non-medullated only as they approach their terminal ends? It is important to determine this because it is, I believe, a well established fact that all vaso-motor nerve fibres are non-medullary from the last ganglion which connects them with their field of distribution. Now, the bundle of nerve fibres shown in the illustration as passing from the pericementum to the pulp are non-medullated. This is very significant. The vaso-motor nerves of the head and face, at least the vaso-constrictor fibril, are distributed from the spinal cord through the cerv-

* Dr. Black, in his excellent work on "The Periosteum and the Peridental Membrane," says, in referring to the sensory functions of the peridental membrane, "That its sensitiveness to painful impressions is not abated by the destruction of the nerves entering by way of the apical space, is sufficiently obvious to all who have had to do with large acute alveolar abscesses producing extensive destruction of the tissues of the apical space."

ical sympathetic. If the vaso-motor nerve fibres of the pulp arise from branches, entering from the pericementum, as seems evident, then their origin is quite clear. In the upper jaw they are distributory branches from the anterior palatine nerve which, arising from the spheno-palatine ganglion, is connected with the sympathetic system through that branch of the vidian nerve which arises from the carotid plexus; and in the inferior maxilla their connection with the sympathetic system is through a nerve branch from the facial artery which enters the sub-maxillar ganglion, through the chorda tympani, and also the otic ganglion from a branch arising from the plexus of the middle meningeal artery. Most vaso-motor nerve fibres of the sympathetic system have been found to possess constrictor and dilator functions, although those of the chorda tympani have been demonstrated to be exclusively vaso-dilator fibres. But it has also been ascertained that when a vaso-motor nerve is severely injured or acted upon by certain medicinal agents the vaso-dilator function persists for some time longer than the vaso-constrictor action. May we not find in this fact an explanation of the action of arsenic in the destruction of the pulp, the first action of the arsenic being the paralyzation of the vaso-constrictor fibrils. The vaso-dilator function continuing, the blood vessels become rapidly engorged and the pulp dies from strangulation. As I see you have put another question to me, an answer to which will involve consideration of the special sensory functions of the pulp, I will defer further discussion of the nerve supply of this organ for a future paper in which I will try to throw a little light on this and some other of your questions.

Blood Supply of the Pulp.

The blood supply of the pulp also arises from two sources, vessels passing from the pericementum and from the medullary canal into the pulp. In a few instances, in recently developed teeth, I have seen small blood vessels passing from the pericementum through the side of the root into the pulp. To my mind, one of the most important facts in this connection is the intricate plexus of very fine blood vessels which I have discovered to be everywhere present in the odontoblast layer of cells in all animals which I have examined including man. This is shown with such diagrammatic clearness in Fig. 12 that I insert this illustration here, although it has appeared once before. In all inflammations of the pulp these must be the first blood vessels to be affected and, considering the intimate relationship between these blood vessels, the odontoblasts and the terminal points of two sets of nerves the clinical signficance must be important. A glance at Fig. 6 from a cross section of the root of a forming tooth shows how freely both pulp and pericementum is supplied with large and small blood vessels. If, there-

fore, it should be established that there is a direct nerve relationship in the control of these blood vessels this, too, will be a fact of considerable clinical importance as you suggest in your question.

The Dentinal Fibrils.

By Dr. J. Leon Williams.

Question 5. "What constitutes the contents of the dentinal tubuli? Is it a liquid? Is it protoplasm? Or is it organized tissue?"

(Comments by Dr. Ottolengui on the above question.)

"It seems to me that the solution of this question must come before we can definitely decide as to the best method of controlling sensitiveness in teeth; for example, is sensation merely a result of pressure upon the contents of the tubes, thus transferring pressure to the terminal nerve filaments in the pulp? If so, and if the contents of the tube are entirely aqueous, then dehydration is all that is necessary in order to obtund, but if the contents of the tube have the power of transmitting sensations which are produced by other means than pressure, the matter is somewhat different."

Answer. To make an answer to this question quite clear and intelligible we must consider the origin of the dentinal fibres. The difficulties in the way of positive conclusions upon this point may be sufficiently indicated by the great diversity of opinion held by well known histologists. Tomes, Kölliker, Waldeyer and many others say the dentinal fibrils arise directly from the odontoblasts and that the fibres are, in fact, prolongations of the cells. Bödecker's final conclusion is that the dentinal fibres arise between the odontoblasts, while Dr. R. R. Andrews and Prof. E. Klein assert that they are prolongations of a special layer of cells occupying a position immediately beneath the odontoblast layer. This means that these different investigators have all seen just such appearances as they have described. I herewith publish several photographs in which evidence in support of all these different views may be seen, and from which two morals may be deduced; one is that in nearly all of her work Nature has more than one phase to present and that, consequently, it is not safe to form conclusions from one or two methods of investigation; and the other is that there are, and probably always will be, some further facts to be learned about all of these different phases.

Glancing at Fig. 7 we observe that there are no fibres projecting from the large, plump odontoblasts but lying between them we see very slender cells which are hardly more than fibres in themselves and from these the dentinal fibrillæ proceed. In Fig. 8 the dentinal fibres most clearly appear to be direct prolongations of the odontoblasts, and if we look at these fibres where they pass over the light interspace at b, we see that the fibre itself is composed of an outer wall, or what has that appearance, and inner granular contents. About the granular nature of the fibre, or of *some* fibres, in developing teeth there is not the least doubt. I have frequently observed this under high power of the microscope. In fact, the contents of the dentinal fibres, as shown in this and other photographs accompanying this paper, are seen to be identical with the cytoplasm of the cells from which they arise. And I further suggest that the so-called "dentinal sheath" or lining of the dentinal tubuli is identical with this outer layer of the fibre as shown in the light interspace just referred to, which outer layer is further seen to be one with the outer layer of the odontoblast itself.

This view is therefore consistent in making the dentinal fibre a portion of the cell itself drawn out through the thickness of the dentine. When, therefore, a dentinal fibre is touched at the periphery of the dentine, an odontoblast, in every practical sense, has been touched. If, as now seems highly probable, we shall be able to establish the proof of a direct nerve relationship with the odontoblast, then the stereotyped utterance of the shrinking patient that the dentist is touching the nerve when he is excavating the outer layer of softened dentine will be seen to be a correct scientific statement.

But there are still many points to be explained in connection with the formation of dentine and the origin of the dentinal fibres. Figs. 9, 10 and 11 show three different phases of the odontoblasts and of dentine formation. In all of these photographs numerous fibres are seen passing upward from the substance of the pulp and entering the odontoblast layer. Some of the fibres appear to pass directly between the odontoblasts and into the forming dentine. In all specimens showing the earliest stages of dentine formation the dentinal fibres do not appear to arise directly from the odontoblasts. In Fig. 9 fibres are seen developing in the very earliest stage of dentine formation even before the odontoblasts are well differentiated. A little later the odontoblasts seem to have fibres projecting from the ends toward the pulp, but none from the ends toward the dentine, see Figs. 10 and 11. The third stage exhibited in Fig. 8 unmistakably shows fibres projecting directly from the odontoblasts into the dentine and also from their inner ends toward the pulp. The organized nature of the dentinal fibre can best be studied by drawing

the pulp very carefully away from the dentine for a little distance, as shown in Fig. 13. If these individual fibres now be examined under a power of 1,000 to 1,500 diameters, they will appear as shown in Figs. 14 and 15, or, at least, many of them will. Others appear to be perfectly smooth and homogeneous. And this suggests what many of the appearances already described do, i. e., that there are fibres entering the dentine from more than one source. Whether this shall finally be demonstrated or not it is clearly evident that there are many fibres entering the dentine which are not the simple, homogeneous substance that the dentinal fibre has always been supposed to be.

I should add that all of the specimens from which these photographs of the dentinal fibres have been made were mounted in glycerine. Probably most of the fine detail here shown would be completely lost in a balsam mounted specimen.

(To be continued.)

SOCIETY PAPERS

The Foundation Principles of Dental Cataphoresis.

By Weston A. Price, D.D.S., Cleveland, O.

Read before the Second District Dental Society, January, 1898.

The detailed, progressive, modifications of application of cataphoresis to the dental organs are determined by great underlying principles, which principles are determined by conditions. It is these conditions, many of which are widely variable, and their relation to the process which we shall consider in this paper.

The process consists essentially, and exclusively in the following discussion, in the medication of a tooth by means of an electric current, where an interposing medicament is used under the electrode, which is in contact with the tooth.

The perfection of the application requires the placing in the tissue to be anesthetized, of a sufficient quantity of the medicament for that purpose. The successful placing of that quantity depends upon the current flowing (amperes), and the conditions of the tissue receiving it. The quantity of current flowing is determined by the pain limit (taking it for granted that we have sufficient voltage for any case). Now on what does this pain limit depend, and to what extent do its limits vary?

Constant and Pulsating Currents.

Before attempting to answer this question it is imperative that we distinguish between the actual pain limit of a tooth for a constant current and the pain limit for a current coming in pulsations. The former implies that the controller is capable of furnishing a current of such perfectly gradual increase of potential, that there will be no pulsations, not even the sudden increase of the five-hundred thousandth part of an ampere, as will be shown later, as required for a perfect instrument, for any case.

The latter, the pulsating current, implies that the controller while apparently furnishing a perfectly gradually increasing current, is actually

furnishing one in a series of steps. Probably steps too small to be detected with ordinary commercial instruments, but very easily detected by the pain organs of the tooth. The practical application of this point to instruments will be made later, but at present we will refer to the method in which this pulsating current establishes a pain limit. All nerve tissues are stimulated to carry impulses of their normal functions, by a variation in the current passing through them. The acuteness of the nerve to receive these stimuli depends largely upon its normal function, which in this particular case, is pain, and is infinitely more acute than that of most other nerves. It is the variations which produce these stimulations, and all who have used cataphoresis on these organs, have observed very closely resembling phenomena in the make and break stimulations, with those of motor nerves.

For a more thorough consideration of the anelectrotonic and cat-electrotonic stimulations of the nerves, reference can be made to any good work on physiology, or to a previous article by the author.

It is true, as has been abundantly established, that every healthy tooth has a definite pain limit for a perfectly constant current. I have been able to establish this frequently, to within the one hundred-thousandth of an ampere, for a variety of total differences of potential, compensating with additional resistance.

To answer this question as to what determines this pain limit, as also other questions we must consider, it becomes necessary for us to make many inquiries which must be answered from clinical data. For example, what are the approximate differences in different teeth? and in the same tooth under different conditions?

The following data, compiled from one hundred and fifty successive cases, has been of the highest importance to me, both for the successful application to the individual cases, and for making general deductions. You will note by the different columns that the amperage and voltage and resistance at both start and finish are given.

The tooth number corresponds with Allport's system of beginning to number from the superior, right, third, molar. Of course the age of the patient, as given, is only a guess, and the time, as shown by remarks, is very often extended to permit of completing another operation. The resistances have been worked out, but have not been corrected for the counter polarization current. Resistances of liquid conductors cannot be measured absolutely, directly, as can metals, by the method we use; but the results, for our purposes, are quite as accurate as we require. In the following, the anode was a small platinum wire, twisted with cotton; and the cathode, two pads on the temples, of large size.

Record of Cataphoric Operations.—(CHART I.)

Serial Number.	Tooth Number.	Start. M. A.	Start. Volts.	Start. Resistance.	Finish. M. A.	Finish. Volts.	Finish. Resistance.	Time.	Size of Cavity.	Medicament.	Approximate Age.	Remarks.
3	2	0.12	5.	41,600	0.4	21.	52,500	15 m.	Large. ⅔ distance to nerve.	Sat. Cocaine in water.	20	Insulation easily effected. Normal condition of teeth was very sensitive. After application no sensation.
4	11	0.093	42.	450,000	.093	42.	450.000	1 hr.	Abrasion nearly to pulp. Secondary deposit of dentin.	Sat. Sol. Cocaine in water.	55	This was a remarkable case of abrasion, both chemical and mechanical. A glossy surface and extremely sensitive. Conditions extreme and demanded the destruction of the pulp. Application was made while inserting another large gold filling. Resistance so high that very slight effect was produced and that very superficial though general. Another sitting made.
5	"	0.13	72.	550,000	0.13	72.	550,000	10	Same as above.	Same as above.	"	The entire surface of cavity was covered with cement and a small hole bored through about bur No. 5. This concentrated the entire energy on a small surface right over pulp. In ten minutes drilled almost to the pulp and lowered the resistance to 275,000 ohms. Reapplied and in fifteen minutes removed pulp entire without sensation.
6	30	.4	3.2	8,000	0.6	5.6	9,330	12	Exposed and suppurating.	Sat. Sol. Cocaine in water.	21	Imperfect insulation. A hole in the rubber. Results middling. Drilled out part of pulp without sensation. Dentalization completed with White's fibre. No pain.
8	1	0.115	5.	43,470	0.5	16.	32,000	40	Abrasion extensive, caries and exposure.	Sat. Sol. Cocaine in water.	13	An exceptionally sensitive patient; teeth hypersensitive. Could not be dried out with cotton. Removed pulp entire without sensation.
9	26	0.105	3.2	256,000	0.125	32.5	260,000	30	Medium.	Sat. Sol. Cocaine in water.	25	A case of exceptionally dense dentine. The anesthesia perfect after running while putting in two gold fillings.

Record of Cataphoric Operations—Continued.

Serial Number.	Tooth Number.	Start. M. A.	Start. Volts.	Start. Resistance.	Finish. M. A.	Finish. Volts.	Finish. Resistance.	Time.	Size of Cavity.	Medicament.	Approximate Age.	Remarks.
10	30	0.21	4.	19,000	0.41	8.6	20,970	10	Large exposure	Sat. Coc. H_2O.	8	Drilled out the pulp without sensation. Devitalized remnants in roots.
11	29	0.4	7.	17,500	0.7	11.	15,710	10	Large Proximal	Sat. Coc. H_2O.	25	In ten minutes sensitiveness all gone. Drilled laterally across tubuli in all sides of cavity without sensation.
12	19	0.2	6.6	33,000	0.6	18.	30,000	15	Very large	Sat. Coc.	12	No sensation, though before it was simply unbearable.
13	11	0.075	5.4	72,000	0.195	42	215,300	20	Large, not exposed	Sat. Coc.	25	While putting in another gold filling was perfectly anesthetized, so that posterior cavity also was not sensitive.
14	18	(a) 0.28	5.3	18,900	(a) 0.35	8.	22,850	10m 2m	Large, not exposed	Sat. Coc.	24	Two applications. First time mostly anesthetized, but some places not enough. Reapplied for two minutes and results perfect.
		(b) 0.4	6.6	16,500	(b) 0.6	8.	13,300					
15	18	0.055	5.3	96,360	0.225	42	186,660	15	Small	Sat. Coc.	21	Perfectly anesthetized while putting in another gold filling.
16	3 & 4	0.185 0.51	5.3 10.6	28,640 20,780	0.405	9.3	23,250	20	Medium	Sat. Coc.	24	Two applications, in two teeth together, and both times the results were much better in one tooth than the other.
17	16	0.13	5.3	28,150	0.41	6.6	16,040	10	Large crown, not exposed	Sat. Coc.	45	Perfect. A simple crown cavity. Easy.
18	30	0.24	5.3	28,083	0.39	6.6	16,920	20 and 10	Large, not exposed	Sat. Coc. and Guiacol	12	The cavity was lined with residual decay which was very sensitive. After first application part was removed without sensation, being in the path of least resistance. Second application removed the rest, but one point high on dentine wall was still sensitive, through which the resistance was very high.
19	19	0.37	8.0	21,620	0.45	9.3	20,660	12	Small	50% Cocaine	40	Small distal cavity, but extremely sensitive. Had been treated with $AgNO_3$. Perfect anesthesia.

Serial Number.	Tooth Number.	Start.			Finish.			Time.	Size of Cavity.	Medicament.	Approximate Age.	Remarks.
		M. A.	Volts.	Resistance.	M. A.	Volts.	Resistance.					
20	31	0.14	5.3	20,240	0.27	5.3	19,620	15	Large exposure	H_2O alone	27	A good test case for the current alone. A large exposure and a hardy, tough man. After using water alone for 15 m. no appreciable difference in sensitiveness, which was extreme. Repeated with saturated sol. of C. and removed pulp without sensation.
		0.31	5.3	15,258	0.88	10.6		15		Sat. Coc.		
21	19	0.36 0.285 0.279	6.6 6.6 6.6	16,800 23,120	0.29 0.279	6.6 6.6 6.6	22,750 23,400 13,200	12 9 8	Large, nearly exposed	Sat. Coc.	26	Three applications. Tooth had been aching hard. A gradual lowering of pain limit. Slight anesthesia. Second trial. Slight results, enough to expose pulp and let pus escape. Third trial perfect.
22	30	0.62	5.3	8,540	1.64	10.6	4,379	12	Large, exposed	Cocaine Sat. Cocaine	10	Removed a very large polypus from the nerve painlessly, but hemorrhage was so profuse that everything was covered. Used **strong** H_2SO_4 as styptic painlessly and applied devitalizing fibre.
23	3	0.121	5.3	42,690	0.19	7.6	40,000	12	Medium	Cocaine Sat.	11	No sensation at first. Was stopped while excavating and when I returned to work found cavity sensitive.
24	12	0.24	5.3	22,080	0.65	10.6	16,300	20	Large suppurating exposure	Cocaine Sat.	16	Entirely removed pulp without sensation.
25	9&10	0.11	7.6	69,090	0.185	16.	84,486	12	Medium, not exposed	Cocaine Sat.	16	Two cavities at once about same size. Prepared both without sensation.
26	7 & 8	0.18	7.6	42,440	0.5	10.6	21,200	12	Two medium	Sat. Coc. in Guiacol	16	Two cavities at once. No. 8 splendid, but No. 7 still sensitive.
27	3	0.0026	1.2	461,616	....	......	....	60	Large	Current only	28	Horton method. Patient said absolutely no difference though every possible combination was made. Tooth extremely sensitive through all. See next case.

Record of Cataphoric Operations—Continued.

Serial Number.	Tooth Number.	Start. M. A.	Start. Volts.	Start. Resistance.	Finish. M. A.	Finish. Volts.	Finish. Resistance.	Time.	Size of Cavity.	Medicament.	Approximate Age.	Remarks.
28	3	0.34	5.3	15,580	0.37	14.6	39,450	10	Large	Sat. Cocaine in Guiacol	28	Same case as 27 with cataphoresis. No sensation on drilling. Perfect success.
29	12&13	0.04	5.3	13,250	0.95	9.3	9,780	20	Both large exposure	Sat. Coc. and Guiacol	30	In 20 m. drilled out both nerves as far as bur would reach.
30	5	0.2	5.3	18,700	0.2	5.3	20,700	10	Large exposure aching	50% Cocaine	27	A fierce toothache. In 10 m. pain had all stopped. Removed debris and re-applied, when all the pulp was removed.
		0.2	5.3		0.8	13.3		15				
31	29	0.065	5.3	53,770	0.14	8.	57,140	10	Large exposure	50% Cocaine	30	A similar case to the last, but had to be filled at the same sitting. First time removed part of pulp and second time remainder, and filled root and crown immediately.
		0.27	8.	29,620	0.55	25.3		20				
32	7	0.2	5.3	26,500	0.2	6.6	33,000	15	Medium	Sat. Coc. in Guiacol	16	Perfect results.
33	19	0.38	5.3	13,940	0.44	8.	18,180	20	Very large	Sat. Coc. and Guiacol in water	13	Drilled out all decay without sensation. Nerve not exposed.
36	dog	(Pulp of	cuspid nerve)	and	(Pulp	of cus musc	pid and le)					
		0.11	2.6	23,630	0.14	2.6	18,570	......	Relative resistance of nerve and muscle tissue	....	....	A dog was chloroformed and his right superior dental nerve dissected out and insulated to the mental foramen. The relative resistance through the path from pulp of cuspid to end of nerve and pulp to an equal distance on the muscle tissue noted as shown.
37	Sheep's Tooth.	1.8	21.	11,660	0.8	21	26,250	15	Exposed pulp	Methyl blue	....	A two-rooted fresh bicuspid of sheep was placed in circuit with current only through one root and methyl blue in cavity. No difference was noted in the extent of permeation.

Serial Number.	Tooth Number.	Start.			Finish.			Time.	Size of Cavity.	Medicament.	Approximate Age.	Remarks.
		M. A.	Volts.	Resistance.	M. A.	Volts.	Resistance.					
38	Sheep's Tooth.	1.2	21.	17,500	... ...	......	....	15	....	Strychnine Sulphate	....	Similar to above in arrangement. Found traces in root in which current was flowing.
39	Sheeps' Jaw	1.06 2.62	12. 12.	11,300 4,420	0.08 0.147	12. 12.	150,000 81,620	....	....	....	..	This was a similar test to No. 36 to determine the relative resistance of path through nerve and muscle. Figures in column called "Start" refer to nerve and muscle paths from pulp of central, and those in column "Finish" refer to same measurements from lateral, both showing a much greater conductivity in the muscle tissue.
40	4 & 5 5 alone 4 alone 5	0.32 0.2 0.1 0.4	5.3 4. 21. 10.6	16,590 20,000 210,000 26,500	0.8 0.9	14.6 16.	18,250 17,770	20 10	5 large exposure, 4 medium	Sat. Cocaine	16	Note difference between Nos. 5 and 4 above. After first application pulp was almost entirely removed from No. 5. Slight sensation in No. 4. Second application removed all from No. 5.
41	Frog	1.0	5.3	5,300	0.7	5.3	7,570	20	Chest to back	Strychnine Sulphate	..	This experiment was made to see if the current actually made any difference in the action of strychnine sulphate on a frog. In about 5 m. the characteristic spasms. The rigid spasms had almost ceased in 10 m. and in 20 m. it was perfectly lifeless. This had been applied for 30 m. the day before without the current and with no effect.
42	19	0.08	2.6	17,480	0.14	2.6	12,765	20	Verylarge, nerve slightly exposed	Sat. Guiacol and Coc. in water	11	Extremely sensitive tooth. Boy had been injured by a street car three weeks before, and his nerves were so sensitive that touching the enamel of any tooth made him cry. Tooth had ached badly. After using had but little trouble removing debris and part of pulp. No pain from devitalizing.

Record of Cataphoric Operations—Continued.

Serial Number.	Tooth Number.	Start. M. A.	Start. Volts.	Start. Resistance.	Finish. M. A.	Finish. Volts.	Finish. Resistance.	Time.	Size of Cavity.	Medicament.	Approximate Age.	Remarks.
43	5	0.3 0.5	5.3 6.6	13,896	0.76 0,78	6.6 8.	....	15 10	Medium large exposed	10% Guiacol and Sat. Cocaine	25	In 15 m. removed decay and part of pulp, and in 10 more the remainder.
44	3	0.6 0.6	5.3 5.3	8,833 8,833	0.7 0.7	6.6 42.	9,428 60,000	12 10	Medium	(1) KI and Guiacol (2) Cocaine Sat. in Water	27	First application no results. On removing anode found it jet black. Later found mistake in place of K. I. bottle. Had used Potassium Iodide in Guiacol. Second Application.
45	Frog.	...	....	No	current.			......	....	....		Placed pledget of cotton soaked with sulp. strychnine on frog's stomach for 30 m. with no apparent physiological effect. See case No. 41.
46	Frog.	1.	8.	8,000	...	....	...	30	Chest and back	Water		Used 1 No. A, as applied with sulphate of strychnine, but with no medicament except water for 30 m., with no apparent physiological effect except a dullness of motor reflexes in hind legs, owing to electrode being over motor centres. See case No. 41.
47	Frog.	2.	7.6	3,800	...	....	....	15 15	....	....		Placed pledget of cotton soaked with mercuric-bichlorid on frog's chest and he went into collapse in 10 m. In 20 m. dead.
48	12	0.2	2.6	13,000	0.8	13.3	16,625	14	Large exposure	Sat. Cocaine and 10% Guiacol		Completely drilled out nerve and filled root, whole operation not exceeding 35 to 40 m.
49	Frog. Nerve m'scle	0.03 0.12	1.3 1.3	43,330 10,830	....	....	....	....	....	Current		The relative resistance of the sciatic nerve and the muscle path to the same point. The foot was immersed in salt water and the other electrode applied, first to cut end of sciatic near lumbar attachment, and second to severed attachment. See resistances.
50	8 & 9	0.2	8.	40,000	0.25	9.3	36,800	20	Small	Sat. Cocaine	11	A very sensitive patient, but the anesthesia perfect.

Serial Number.	Tooth Number.	Start.			Finish.			Time.	Size of Cavity.	Medicament.	Approximate Age.	Remarks.
		M. A.	Volts.	Resistance.	M. A.	Volts.	Resistance.					
51	8	0.15	5.3	35,330	0.2	8.	40,000	12	Medium	Cocaine 10%	11	Perfect results.
52	7	0.2	5.3	26,500	0.38	12.	31,500	15	Medium	Cocaine 10%	30	Perfect results, though the tooth was so extremely sensitive before.
53	....	0.2	4.	20,000	0.6	6.6	11,000	10	Large	Cocaine 10%	11	Only medium results, owing to position of cavity could not perfectly insulate.
54	14	0.2 0.25	5.3 8.8	26,500 32,000	0.25 0.3	6.6 9.3	26,400 31,000	10 10	Large, exposed	Sat. Cocaine in Water.	26	First results not perfect because of leakage. Second application perfect. Removed pulp. Tooth had been aching very hard.
55	....	0.1	2.6	26,000	0.8	8.	10,000	12	Large, nerve exposed	Sat. Cocaine	24	After 10 m. the amperage suddenly increased, showing leakage. It was removed and results sufficient to remove part of pulp, rest devitalized.
56	31	0.2	5.3	26,500	0.58	9.3	16,030	12	Large exposure	Sat. Cocaine	30	Drilled out nerve without sensation. Partly sloughed away.
57	18	0.2	5.3	26,500	0.62	9.3	15,000	12	Very large exposure	Saturated Solution of Cocaine	16	Drilled out exposed pulp without pain. Had been aching hard for some time. Perfect results.
58	Gum	2.4	8.	3,330	....	....	....	5	Used on gum	Cocaine	20	Used for root extraction, gum well anesthetized.
59	4	0.22	6.6	30,000	0.3	10.6	3,530	10	Large	10% Cocaine	17	Perfectly anesthetized.
60	9	0.35	5.3	15,100	0.4	16.	40,000	10	Large	Sat. Cocaine	30	Perfectly anesthetized, pulp slightly exposed and capped.
61	3 & 4	0.15	4.	26,330	0.5	9.3	18,600	13	Large	Sat. Cocaine	26	Both perfectly anesthetized.
62	28 & 29	0.1	2.6	26,000	0.4	14.6	36,500	12	Both large	Sat. Cocaine	30	Both perfectly anesthetized.

Record of Cataphoric Operations—Continued.

Serial Number.	Tooth Number.	Start. M. A.	Start. Volts.	Start. Resistance.	Finish. M. A.	Finish. Volts.	Finish. Resistance.	Time.	Size of Cavity.	Medicament.	Approximate Age.	Remarks.
63	31	0.25	6.6	26,400	0.3	9.3	31,000	12	Large	Sat. Cocaine	16	No sensation except at one point in drilling across tubuli.
64	29	0.1	4.3	43,000	0.2	....	35,150	20	Large	Sat. Cocaine	18	Good, though a bad case to insulate from other fillings. Chlora percha used freely.
65	30	0.12	5.3	44,160	0.5	17.3	34,600	13	Medium	Sat. Cocaine	..	Compound cavity, but no sensation in preparation, except in a deep lateral undercut.
66	18	0.15	4.	26,660	0.32	8.	25,000	12	Medium	Sat. Cocaine	17	Drilled out without sensation, except when going across the tubuli in one direction in an undercut.
67	11	0.17	5.3	31,170	0.6	21.	35,000	10	Large exposure	Sat. Cocaine	22	Completely drilled out exposed nerve without a particle of sensation. Badly suppurated.
68	27	0.2 0.2	5.3 5.3	26,500 26,500	1. 0.8	9.3 12.	9,300 15,000	10 10	Very large exposure	Sat. Cocaine	38	The rubber slipped up enough to allow a break in the insulation as shown by the resistance. It was taken off and reapplied and a second application made, when every particle of the pulp was removed without sensation, evidently a very large apical foramen.
69	7	0.05	2.6	52,000	0.25	21.	84,000	10	Medium	Sat. Cocaine	15	Did excavating without a particle of sensation.
70	2	0.2	8.	40,000	0.6	12.	20,000	10	Small	Sat. Cocaine	26	Perfect results, although the current was leaking toward the last, as shown by the resistance.
71	28 & 29	0.3 x. 1.01	6.6 5.3 5.3	22,000 53,000 75,704	0.4 0.2 0.3	8. 10.6 21.	20,000 23,000 70,000	10 20 10	28 Large 29 Small	Sat. Cocaine first. Guiacol and Cocaine	28	A remarkable case. Two cavities were tried together for 10 m., when the small one showed no sensitiveness and, the large one did, which was a large exposure. Reapplied on large exposure for 20 m. when partially removed. Reapplied for 10 m. and removed all of remainder of pulp. Root was filled at the time. The apical foramen was too small to find with the smallest broach.

Serial Number.	Tooth Number.	Start.			Finish.			Time.	Size of Cavity.	Medicament.	Approximate Age.	Remarks.
		M. A.	Volts.	Resistance.	M. A.	Volts.	Resistance.					
72	8	0.1	6.6	66,000	0.32	21.	65 620	12	Large	Sat. Cocaine	17	Perfect results. Nerve not exposed.
73	9	0.1	8.	80,000	0.35	21.	60,000	12	Small	Sat. Cocaine	23	Perfect results.
74	19	0.12 0.23 0.15	4. 5.3 9.3	33,330 23,040 62,000	0.25 0.32 0.7	8. 9.3 21.	32,000 26,844 30,000	10 20 8	Large exposure	Sat. Guiacol and Coc. Sat. Coc. in H_2O	25	In 10 m. drilled out part of pulp, but ant. root very sensitive. Reapplied for 20 m. and could not increase the current as ordinarily, and the ant. root still sensitive, though posterior, not even beyond the tip, through a large foramen. Removed pulp from posterior root and filled with an insulator and reapplied for 8 m. Found resistance much increased in ant. root alone. Removed all pulp without sensation.
75	30	0.12	6.6	55,000	0.4	21.	52,500	14	Large under gum	Sat. Cocaine H_2O	23	Perfect results. Insulation difficult.
76	10	0.05	13.3	266,000	0.15	42.	....	8	Very small	Guiacol and Sat. Cocaine	17	Splendid. Was extreme.
77	8	0.13	5.3	40,760	.3	21.	70,000	15	Large	H_2O Cocaine	12	One of the most sensitive patients in the country. Absolutely no sensation.
78	30	0.12	5.3	44,160	0.45	12.	....	16	Large exposure	Sat. Cocaine H_2O	26	Drilled out large suppurating pulp without sensation, except in extreme tips of roots.

Record of Cataphoric Operations—Concluded.

Serial Number.	Tooth Number.	Start.			Finish.			Time.	Size of Cavity.	Medicament.	Approximate Age.	Remarks.
		M. A.	Volts.	Resistance.	M. A.	Volts.	Resistance.					
79	20	0.3 0.2	2.6 5.3	86,600 26,500	0.15	5.3	35,350	25	Large	Sat. Cocaine H_2O	27	A remarkable case. A nurse who had not slept for 48 hours. Tooth aching for a month. Too sensitive to dry with cotton pledget. M. A. constantly decreased for some time. Closer examination showed remnant of old cement filling over pulp which, when removed, allowed pus to escape. Reapplied, but could not remove all of pulp tissue. Devit. with fibre and when filling root found apical foramen very small, and resistance through root walls very low.
80	......	0.15	5.3	35,330	0.4	9.	22,500	12	Medium	H_2O Sat. Coc.	20	Completely anesthetized, but a recurrence after five minutes.
81	19	0.15	5.3	35,330	0.5	10.6	2 .,200	20	Very large	Sat. Coc. H_2O	26	Completely removed pulp without sensation.
82	19	0.11	5.3	46,360	0.22	6.6	30,000	12	Large	Sat. Coc. H_2O	12	Perfect results.
83	29	0.1	4.	40,000	0.2	8.	40,000	15	Medium	Sat. Coc. H_2O	40	Perfectly anesthetized while putting in gold filling in No. 26.
84	29&30	0.21	5.3	25,230	0.46	8.	17,390	12	Both medium large	Sat. Coc. H_2O	20	Perfect results.
85	7	0.13	9.3	71,540	0.2	21.	105,000	12	Medium	Sat. Coc. H_2O	24	Perfect results, but a recurrence in five minutes.
86 ...	8 & 9	0.1 0.37	4. 10.2	40,000	0.2 0.41	8. 18.2	40,000 ...	18 10	Large both	Sat. H_2O Cocaine	28 ..	Quite perfect results in 9, but not in 8. Reapplied and good in both.
87	1	0.08	4.	50,000	0.45	9.3	20,630	17	Large	5% Cocaine H_2O	25	A hard patient, but perfect results.
88	13	0.08 0.12	5.3 9.3	66,250 77,500	0.2 0.23	10.6 32.0	53,000	... 25	Medium	Coc. Sat. H_2O	26 ..	A skeptical patient and teeth very sensitive. Touching the dentine unbearable. After using dentine did not hurt as much as the enamel when being drilled.

Serial Number.	Tooth Number.	Start.			Finish.			Time.	Size of Cavity.	Medicament.	Approximate Age.	Remarks.
		M. A.	Volts.	Resistance.	M. A.	Volts.	Resistance.					
89	Gums	1.2	6.6	5,500	1.6	6.6	4,120	3	....	Brass Electrode in 50% H_2SO_4	50	Pyorrhœa, very deep pockets. Tooth elongating. Pockets washed with $H2SO_4$ 50%, and a brass electrode used in same solution. In three months no recurrence of pus. Three treatments were given.
90	14	0.1 0.28	4. 5.3	35,720	0.4 0.6	8. 10.6	20,000 17,660	20 10	Medium large	Sat. Cocaine H. 2°	30	Drilled out all of decay and found a large suppurating exposure. Reapplied for 10 m. and drilled out all except small buccal root which was devit. No sensation.
91	14	0.1	2.6	26,000	0.5	6.6	13,020	12	Medium large	Sat. Cocaine H. 2°	17	Perfect results, not exposed.
92	5	0.08	2.6	32,500	0.33	8.	....	15	Exposure large	Sat. Coc. H. 2°	26	Completely extirpated without pain.
93	4 & 5	0.13	4.	30,710	0.6	10.6	17,096	17	4 Exposed 5 Large	Sat. Coc. H. 2°	14	Perfect results. Hysterical patient. No. 5 large exposure. Removed pulp on broach and filled root without patient's knowledge.
94	28	0.25	9.3	37,200	0.32	16.	50,000	10	Small	Sat. Coc. H. 2°	35	Splendid.
95	8 & 9	0.08	4.	50,000	0.1	5.3	53,000	8	Both medium	Sat. Coc. H. 2°	28	Perfect.
96	......	0.07 0.4	2.6 6.6	37,140 15,860	0.4 0.85	6.6 10.6	16,500	17 7	Very large exposure	Sat. Coc. H. 2°	27	Tooth had been aching hard. Pain ceased quickly. Removed part of pulp and devit. No pain from devitalizing whatever.
97	30	0.07	2.6	37,140	0.5	9.3	18,600	20	Very large not expos.	Sat. Coc. H. 2°	18	While cementing crown for another patient, completely anesthetized this tooth.
98	31	0.08	2.6	32,500	0.6	8.	13,330	8	Very large	Sat. Coc. H. 2°	26	Tooth excruciatingly sensitive. Perfect results.
99	4	0.15	5.3	35,330	0.4	10.6	26,250	16	Large	Sat. Coc. H. 2°	25	Perfect results.
100	11	0.1 0.35	5.3 8.	53,000	0.3 0.7	8. 12.	26,660 17,140	20	Very large	Sat. Coc. H. 2°	28	Perfect results.

Averages of Results.

Average pain limit (Mill. amps.), at start of first 50 cases	0.245
" voltage at start of first 50 cases	8.51
" resistance at start of first 50 cases	34,730 ohms.
" pain limit (Mill. amps.), at finish of first 50 cases	0.482
" voltage at finish of first 50 cases	12.25
" resistance at finish of first 50 cases	25,410 ohms.
" pain limit (Mill. amps.), at start of second 50 cases	0.155
" voltage at start of second 50 cases	5.2
" resistance at start of second 50 cases	33,540 ohms.
" pain limit (Mill. amps.), at finish of second 50 cases	0.406
" voltage at finish of second 50 cases	18.
" resistance at finish of second 50 cases	42,330 ohms.

Minimum pain limit at start 0.01 mill. amp. or $\frac{1}{100000}$ amperes. In 17 per cent. the pain limit at start was less than 0.1 mill. amp. or $\frac{1}{10000}$ amperes. No commercial mill. amp. meter on the market at present would give a clear reading of these 17 cases.

From the foregoing clinical data we are able to make very valuable deductions, with which we can, in connection with the laws of electro-physics and electro-chemistry, explain and determine most of the phenomena of dental cataphoresis.

Some of these are as follows:

Deductions from Records.

1. The relation of the results to the amperage is in direct proportion in most cases; but not where the result desired is to anesthetize a part of the tooth which is of relatively high resistance as compared with other parts of the path, as for example, the margins of a cavity, where the center of it is near the pulp, or where removing the pulp from a root, where the lateral resistance through the root walls is less than through the apex.

2. The results are not directly related to the resistance alone for if the pain limit will permit, this is overcome by an increase of voltage. There are some conditions, however, where the pain limit will not permit, as for example, case 74.

3. The time is usually in inverse proportion to the amperage. The exceptions are the same as in the first.

4. There is not a definite relation between the time and the resistance, though very often they are in direct proportion, the reason for which will be shown later.

5. There is not necessarily a relation between the extent of surface of dentine exposed, and the time, though there is a very definite relation between the results, and the relative resistance through different parts of that surface.

6. There is a constant relation between time and results.

7. The pain limit is very widely variable.

8. The resistance of teeth is markedly in direct proportion to the age of patient.

9. The pain limit is usually in indirect proportion to the age of patient.

From these observations it becomes clearly evident that the same relation of conditions does not exist when working in the roots as when working in the cavity, where the pulp is not exposed, for there seems to be an almost constant relation between the results and current in the latter, but not at all in the former. Now the amperage, or quantity of current, flowing, is the expression of the pain limit, hence the pain limit, or its source, does not bear the same relation to our work in preparing a cavity as it does in removing the pulp from roots.

These facts led me to investigate the relative resistance through the root walls of teeth, and through their apical foramena. The results were very startling to me, as no doubt they may be to some of you. Note the difference in the resistance of teeth in and out of the mouth, though all the latter had been soaking for weeks in water containing a few drops of camphophenique, simply to sterilize. (See Chart 2 and 3.)

Direction of Current Flow.

From these readings it is clearly evident that we have been mistaken in our assumption that the current was mostly all going through the tip of the root. On the contrary, it is an entire uncertainty which way the current is going, through the apical foramen or through the walls of a root. This at once explains why so often when we are trying to anesthetize the last remnant of pulp from a root it takes so much longer time than we should expect. Of course the ratio of the current flowing laterally through the walls is to that flowing through the apical foramen, as the resistance of the latter is to the former and the same relation exists between the different roots, if more than one, which accounts for the fact that often we can remove the pulp from one root long before we can from the other. In this case, if you will pardon a suggestion outside of the subject, before proceeding plug up the root from which you first remove the pulp tissue with an insulator. I have carefully prepared a table of resistance through the various sizes of apical foramena, taken from actual cases and have compared them with those observed in various sized openings in a tip of a glass tube drawn to as near as possible the shape of a pulp chamber in a single rooted tooth. You will observe that the resistances are in good relation, though higher in the tooth than in the glass tube, probably because in the former there are shreds of tissues which partially close the foramen.

Resistances Through Moist Teeth to Mercury Bath, Voltage 20. External Resistance in Circuit, to Protect Instruments, 2,700 Ohms.—(CHART II.)

Serial Number.	Tooth.	From cavity pulp not exposed.		From exposed pulp.		From pulp chamber through root walls, tips sealed.		From pulp chamber through tips, with walls sealed.		Lingual or single or anterior roots, tip sealed.		Buccal or posterior roots, tip sealed.	
		M. amp.	Resistance.	M. amp.	Resistance.	M. amp.	Resistance.	M. amp.	Resistance.	M. amp	Resistance.	M. amp.	Resistance.
1	Bicuspid....	0.2	99,700	1.0	17,300	Not exposed.		Not exposed.		Not exposed upper half.		Pulp exposed, upper half.	
						0.04	473,000	0.5	437,300	0.01	1,997,300	0.2	99,700
						Exposed.		Exposed.		Lower half.		Lower half.	
						0.8	22,300	0.2	99,700	0.01	1,997,300	0.6	30,630
2	Lower molar........	0.2	99,700	0.6	30,630	Not exposed anterior root.		Anterior root.		Upper half, not exposed.		Upper half, not exposed.	
						0.1	197,300	0.1	197,300	0.02	997,000	0.02	997,000
						Posterior root.		Posterior root.		Pulp exposed.		Pulp exposed.	
						0.13	130,630	0.1	197,300	0.2	997,000	0.2	99,700
						Exposed pulp, anterior root.				Lower half pulp exposed.		Lower half, pulp exposed.	
						0.2	99,700			0.1	197,300	0.3	63,630
						Posterior root.							
						0.4	47,300						
3	Bicuspid....	..	....	1.3	12,680	0.8	22,300	0.23	84,256	Pulp exposed, upper half.		Same root pulp exp., l. half.	
										0.6	30,630	0.2	99,700
4	Upper molar........	1.0	17,300	1.3	12,680	Not exposed anterior root.		Not exposed anterior root.					
						0.22	997,000	0.02	997,000				
						Posterior root.		Exposed.		Pulp exposed, upper half.			
						0.01	1,997,000	0.2	99,700	0.6	30,630		
								Not exposed posterior root.		Lingual exposed.			
								0.01	1,997,000	0.02	997,000		
								Exposed.		Pulp exposed.			
5	Lower molar........	..	....	1.75	7,720	Exposed anterior root.		0.1	197,300	0.4	47,300		
						1.1	15,480	Exposed anterior root.		Anterior and buccal roots, upper half not exposed.			
						Posterior root.		0.3	63,960	0.6	30,630		
						0.3	63,960	Posterior root.		Lower half.			
6	Lower wisdom......	0.8	22,300	1.6	9,800	Not exposed.		0.05	437,300	0.8	22,300		
						0.6	30,630	Not exposed.					
						Exposed.		0.2	99,700				
						1.3	12,680	Exposed.					
7		..	....	0.67	27,150	0.57	33,387	0.3	63,960				
								0.1	197,300	Pulp exposed, upper half.			
										0.4	47,300		
										Lower half.			
8	Lower wisdom......	..	....	0.62	29,558	0.5	37,300			0.12	163,966		
								0.12	163,966	Pulp exposed, upper half.			
										0.4	47,300		
										Lower half.			
9	Bicuspid....	..	....	0.7	25,870	0.4	47,300			0.2	99,700		
								0.3	33,960	Pulp exposed, upper half.		Same root, lower half.	
10	Upper wisdom......	0.6	30,630	0.8	22,300	Not exposed.				0.17	114,947	0.2	99,700
						0.2	99,700	Not exposed.		Not exposed upper half.		Same root pulp exp., u. half.	
						Exposed.		0.01	1,997,300	0.2	99,700	0.2	99,700
						0.5	37,300	Exposed.		Lower ha.f.		Lower half.	
								0.3	63,960	0.02	997,000	0.3	63,960
11	Two-rooted bicuspid..	..	....	1.3	12,680	0.5	37,300	0.8	22,300	0.2	99,700	0.3	63,960

Resistances Through Moist Teeth to Mercury Bath, Voltage 20. External Resistance in Circuit, 2,700 Ohms.

(CHART III.)

Serial No.	Tooth old, soaked in water.	From pulp chamber through root walls, tips sealed.		From pulp chamber through tips, walls sealed.		From pulp chamber, through tips and walls.	
		M.amp.	Resistance.	M.amp.	Resistance.	M.amp.	Resistance.
12	Upper molar...........	0.6	30,630	2.4	5,633	3.0	3,966
13	Two-rooted bicuspid......	0.2	99,700	0.1	197,300	0.3	63,900
14	Upper molar............	0.6	30,630	0 3	63,960	0.9	19,620
15	Upper molar	0.6	30,630	0.6	30,630	1.2	13,960
16	Lower molar	0.05	473,300	0.2	99,700	0.25	77,300
17	Lower molar	2.1	6,823	1.4	11,580	3.5	3,014
18	Upper molar.............	0.4	47,300	0.2	99,700	0.6	30,630
19	Lower molar	1.0	17,300	1.1	15,480	2.1	6,823
	Upper molar	0.7	25,870	0.5	37,300	1.2	13,960
				Lingual.			
				0.3	63,960		
				Buccal.			
				0.2	99,700		
21	Upper molar	0.2	99,700	0.85	20,829	1.05	16,347
22	Upper molar	0.1	197,300	0.2	99,700	0.3	63,960
				Lingual.			
				0.05	437,300		
				Buccal.			
				0.15	130,633		

Fresh Teeth Readings Taken Immediately After Extraction.

23	Upper molar	0.6	30,630	0.3	63,960	0.9	19,620
				Lingual.			
				0.1	197,300		
				Buccal.			
				0.2	99,700		
24	Child's tooth	..	....	1.1	15,980	1.8	8,110
25	Old man's 3d lower molar	0.6	30,630	0.4	47,300	1.0	17,300
26	Old man's 2d lower molar	0.3	63,960	0.2	99,700	0.5	37,300

In any case except a young patient it would seem that the resistance is just as likely as not to be greater through the foramen than through the walls of the root. (See Chart 4.)

These diameters were determined by placing in the opening to be measured, as through the apical foramen, a very fine, gradually tapering, steel broach, specially prepared, and measuring its diameter at point of contact. I have measured the resistances of many cases in the mouth by taking readings before drying for root filling, and then again filling the end of the root, and have, by associating these readings with the previous

Resistance Through Apical Foramena of Increasing Size. Voltage 20. External Resistance in Series, 2,700 Ohms.

(CHART IV.)

Teeth Roots.			Drawn Glass Tube.		
Diam., 1000th inch.	M. Amp.	Resistance.	Diameter, 1000th of an inch.	M. Amp.	Resistance.
9	0.4	47,300			
11	0.5	37,300	1	0.12	163,966
12	0.52	35,762	1.5	0.2	99,700
14	0.6	30,630	2	0.32	59,800
15	0.8	22,300	3	0.41	46,080
16	1.2	13,460	4	0.6	30,630
18	1.3	12,680	5	0.8	22,300
19	1.4	11,550	6	0.9	19,620
			7	1.1	15,480
6	0.3	63,960	8	1.8	8,410
7	0.4	47,300	9	2.4	5,633
9	0.5	37,300	10	2.8	4,442
10	0.52	35,762	11	3.1	3,751
11	0.6	30,630	12		
12	0.7	25,870	13	3.2	3,550
14	0.72	25,077	14	3.5	3,014
			15	4.2	2,061

records of pain limit, and results in removing pulp tissue, come very forcibly to the conclusion that almost invariably the pain limit is determined in the apical foramen. The exceptions are easily distinguished, and easily explained. If this be so, it will account largely for the actual results of experience.

Physical Effects of Electricity.

Just here, let us consider some of the physical effects of an electric current. One of these is the production of heat. From the law of the conservation of energy, we know that energy cannot be created or lost; hence the energy lost, as electric energy, by an electric current, in passing through a conductor, is not lost, but must change to an equivalent of some other kind of energy. In a metallic conductor the loss of electrical energy is practically all changed to heat. In fact, in any system of a homogeneous conductor, the heat generated by the passage of a current can be absolutely calculated by knowing two things, the fall of potential and the amperage, or the resistance and the amperage. In brief, it is expressed as follows: "The heat developed in a homogeneous portion of any circuit, is equal to the square of the current in the circuit multiplied by the resistance of that portion." This is known as Joule's law. It holds good for any homogeneous circuit, or for all parts that are homogeneous.

There are modifications of conditions which may enter to make the circuit non-homogeneous, as for example, the difference of potential between a metal and a liquid, or two liquids, or the chemical changes taking place. If a gas is evolved, of course heat is absorbed. The increase, in the system, of chemical energy which would demonstrate itself as a counter, or polarization, current of the electrolysis, is also to be subtracted to make an absolute calculation. For our present purpose these may be neglected as they will practically be proportional in the different parts.

Let us suppose a practical case. A single rooted tooth, for simplicity say a central incisor, with large mesio-proximal cavity, extending half way to the pulp.

Heat Generated by Current.

Suppose the milliampere meter reads 0.4 and voltage is 25. Then the resistance of the circuit is 62,500 ohms; neglecting the polarization current.

Let us suppose the resistance through the dentine from the cavity to the pulp is 10,000 ohms, and from the pulp to the tissue, around the tooth, 45,000 ohms, and from this point to the negative electrode 7,500 ohms. Suppose, for simplicity, that the resistance from the pulp through the root walls is equal to that through the apical foramen. Then the path of our current will be, provided our cavity is perfectly insulated, as follows: All of it through the cavity and dentine to the pulp, and thence one-half through the root walls and one-half through the apical foramen, and thence to the negative electrode. As the current leaves the pulp, it has two paths, whose combined resistance is 45,000 ohms. Since the combined resistance of any shunt is equal to the product of the individual resistances of the paths divided by their sum, then the resistance of each of these two paths must be 90,000 ohms. Now, applying Joule's law to the various parts of this circuit, we have, the heat generated in the dentine between the cavity and pulp, represented as below; using the centi-gram-second system of units, which we shall use exclusively. This will require us to express our previous equation: Amperes^2 × Ohms × .236 = Calories. ($a^2 \times O \times 0.236 = C.$)

A calorie is the amount of heat required to raise one gramme of distilled water one degree centigrade.

Hence $0.0004^2 \times 10{,}000 \times 0.236$ = calories of heat developed in 1 second in the dentine = 0.0003776. But one calorie is the amount of heat necessary to raise one cubic centimeter of distilled water, one degree centigrade, for 1 gramme = 1 cubic centimeter of distilled water at its maximum density (4° C.); therefore to express the actual rise of temperature in this part of the circuit, per second, we must determine the volume of matter heated, and express it in cubic centimeters, for

the rise of temperature is in inverse ratio to the volume. We must also know the specific heat of the substance, for if the matter in question has a greater or less specific heat than water, it would experience a relatively less or greater change of temperature, from the same heat unit. As a matter of fact, the specific heat of blood is slightly less than that of water; 1 calorie would raise that amount of blood more than 1 degree C. Since the tissues we must consider are so variable and complicated, and since the error from this source will be comparatively small, we shall not complicate the consideration with this correction.

I have cut out a section of dentine corresponding as nearly as possible to that portion through which the current was passing in the case we are supposing, and found its volume to be 0.001727 C. Cm. This was determined by displacement in a small capillary tube. Applying this to our calculated heat developed, we get $0.0003776 \times 580 =$ Rise of temperature in the dentine in 1 sec. in degrees centigrade $= 0.219$, and expressed in Fahrenheit, 0.394°.

If this elevation of temperature were quite evenly distributed through the dentine lying in the path of the current, it should not produce discomfort. As a matter of fact, however, it will not be evenly distributed for two reasons. The resistance through the different parts of the dentine will vary largely; and again the current is conveyed through the dentine by the contents of the dentinal tubes whose total cross sectional area, and also volume, is very much less than that of the lime salts. If these tubuli were all the same size and length, the heat would be relatively evenly distributed throughout the entire volume of dentine in the path, but the actual heat produced in any one of them would be much more than that we have calculated. If the volume of the conducting matter in the tubuli is relatively very much less than that of the dentine surrounding them, then the rise of temperature in them will be inversely greater, and in the ratio of their volumes.

The current is practically all conducted by the animal matter which constitutes 28 parts of normal dentine by weight. If the ratio of the specific volume of these two substances were the same as the ratio of their specific weights, we could substitute; but they are not. The specific weight of dentine, with animal matter extracted, is more than 20 per cent. greater than that of animal matter. This will make the specific volume of the animal matter about 33 per cent. in ordinary dentine. Now, if all the tubuli are helping alike to carry the current, that is, have the same size and length, then the rise of temperature in each one will be three times greater than we have calculated, or 0.657° C., or 1.182° F. This should not produce pain.

Let us proceed in the same way and determine the heat developed

in the other parts of this circuit. In thé body beyond the tooth the resistance is 7,500 ohms, and the amperage 0.0004. Then the total heat developed in this part of the circuit is $7{,}500 \times 0.0004^2 \times 0.236 =$ Calories $= 0.00028$. This quantity of heat is developed in very many times the unit of volume, 1 C. C. M., hence the rise of temperature will be relatively that much less.

As a matter of fact, by far the larger part of this resistance through the patient, is found in the external layers of the skin, which fact, associated with Joule's law, explains why we get a tickling sensation on the point of contact of a constant current, and not a tickling throughout the circuit. This has nothing to do with the sensation felt from a pulsation of current as a make or break. If most of the total current flowing is passing through the skin, through one or more minute areas, as through a hair follicle, or from a small point of any kind, we should get a sensation with a very low amperage. Hence use just as large an indifferent electrode as possible, both to reduce the total resistance of the circuit, and to diminish the possibility of sensation at that point.

Let us now determine the heat generated by the passage of the current through the root walls. Through this path we have 0.0002 amperes of current flowing, and the resistance is 90,000 ohms. The total heat generated is $0.0002^2 \times 90{,}000 \times 0.236$ Calories $= 0.0008496$.

If the volume in which this is developed is more or less than 1 C. Cm., the rise of temperature will be less or more than this number of degrees centigrade. The total volume of substance in the root walls is probably occasionally as great as one-half a C. Cm., though generally less. In a central of average size it is probably about one-fourth. It would be practically impossible to determine the relative volume of the conducting matter, and the non-conducting matter of the substance of the root walls, without an analysis, but we know that since the surface is so great, the concentration of heat will not be great enough in the individual tubuli to cause much rise of temperature, provided the tubuli are comparatively uniform in size and length, or in other words, of uniform conductivity.

Let us now determine the heat developed in the apical foramen in this case. It is $0.0002^2 \times 90{,}000 \times 0.236$ Calories $= 0.0008496$. If this were in a substance whose volume was 1 C. Cm., and whose specific heat was the same as that of water, the elevation of temperature in one second would be the above number of degrees C. But the volume is very much less.

We will assume without considerable error that the specific heat of the contents of the apical foramen is the same as that of water. The next thing for us to determine is the volume of the conducting matter

in the apical foramen, through which the resistance is 90,000 ohms, and express it in terms of the unit 1 C. Cm. of water. This is one of the most difficult considerations we have, but I think it can be done very approximately. First we must determine how far up the pulp tissue we must consider. By measuring the resistance through the apical foramen of a root, and then gradually cutting it back from the tip, making readings frequently, it is easy to determine the relative resistance of the different areas. This can also be done by enlarging the same foramen and noting the resistance of certain measured sizes of openings. In this way I have determined that in all cases where the pulp chamber suddenly contracts at the apex, as most canals do, the resistance is almost **all** in the last one-eighth or often one-twentieth of an inch. For this reason, in these considerations I have neglected the resistance through pulp tissue, since relatively it is very small as compared with the other parts of the teeth. In the determination we are to make of this root, I have taken the tissue for about 3 millimeters. It is practically an impossibility to take the tissue from the root of one of these cases, and measure it; it must be done by other means. In order to use the same units which we have been using, the substance used instead of pulp tissue must have as nearly as possible the same specific weight as that tissue, and must be something we can handle. Since green hard wood and blood and water have so nearly the same specific weight, which means the same specific volume, we can substitute this substance for the pulp tissue, and still retain the same units, besides having something we can shape and handle.

From the table of observed resistances, I would say that to have 90,000 ohms resistance, the apical foramen would be about four-thousandths of an inch in diameter.

According to these requirements I have prepared from green applewood, as nearly as possible, fac-similes of the shape and volume of the tissue in various sized apical foramena. These being of the same specific weight as water, could by their weight express the volume of the tissue in question in C. Cm. For the absolute weight of these while green, I am entirely indebted to Dr. Miller, Professor of Physics of Case School of Applied Science. He was able to weigh them to within one-ten-thousandth part of a gram. These show that the weight of the tissue in question for the particular case which we are now considering, as nearly as I could prepare the specimen, was 0.21 milligrams, or since its specific volume is the same as that of water, approximately, its volume is 0.00021 C. Cm. Therefore the rise of temperature in this part of the path is

$$0.0008496 \times \frac{100000}{21} = 4.04$$ degrees Centigrade, or 7.27° F. Of course

the surrounding tissues would absorb heat more or less rapidly, but it is to be remembered that this quantity of heat is being liberated every second. It seems very convincing to me that it is at this point that the pain limit is determined in the case which we are considering, as indeed in most cases.

Relation of Heat to Pain Limit.

Now let us imagine some modifications of this case. Suppose the resistance through the dentine is 1,000 ohms instead of 10,000. What will be the changes of phenomena? The resistance of the circuit will be 53,000 ohms. Very clearly the pain limit will not change, so the milliampere meter will read the same. Really the only difference it will make will be that it will require less voltage, which will be 21.3 instead of 25.

Suppose the resistance through the dentine be 100,000 ohms. This will mean that for the same pain limit the voltage would be 61. In this case the heat generated in the dentine would be $100{,}000 \times 0.0004^2 \times 0.236$ calories, which, using the same conditions of cavity which we had before, would make a rise of temperature in the conducting medium of the dentine of 9.2° C., or 16.7° F. This would probably be almost the same concentration of heat which we had in the apex, and if the conducting tissue of the dentine were more sensitive than that at the apex, we would probably have the pain limit determined at this point. Now, suppose it is, and suppose you were able to increase the amperage to only 0.0003, what will be the effect of cutting out part of this dentine?

Of course it will lower the resistance of the circuit, but besides, if the pain limit is determined at this point, we will find by a new application, that the pain limit has raised. It is in this way that we are able frequently to determine just where the pain limit is being determined, as in case No. 5.

Suppose now the resistance through the walls of the root of this tooth were 200,000 ohms; then the combined resistance of this path and shunt would be $(200{,}000 \times 90{,}000) \div (200{,}000 + 90{,}000) = 62{,}060$ ohms, and the resistance of the circuit would be 79.560. The pain limit would clearly be found at the same place, though to produce the same concentration of heat at that point, the total amperage would not be so great. The pain limit of that apex is 0.0002 amperes, and the current flowing through these two paths is in inverse proportion to their resistance, hence the current flowing through the walls will be 0.00009 amperes, and the total .00029. This will require a potential of 23. volts. Here we have lowered the voltage by increasing the resistance; an apparent absurdity, nevertheless it is true.

Again, let us suppose the same case, but with the resistance through the root walls only 10,000 ohms. In this case the resistance of this part of the path, the two way part, will be: $90{,}000 \times 10{,}000 \div (90{,}000 + 10{,}000) = 9{,}000$, and the total resistance of the circuit is 26,500.

The pain limit of the apex is constant at 0.0002 amperes, and therefore the current flowing through the walls is to 0.0002 as 90,000 is to 10,000, or is .0018. Then the total current flowing is $0.0018 + 0.0002 = 0.002$ amperes, or 2 milliamperes, with a voltage of 53. This would undoubtedly produce pain in the dentine, and the pain limit would in this case be determined in the dentine. On cutting out a part of the dentine, and taking a new reading of the pain limit, we would find it proportionately changed. This condition would be hard to identify unless you undertook to remove the pulp from the root, when you would be very much chagrined and surprised at the incredible length of time required as compared with the amperage. I have measured cases in the mouth that had given just such trouble in removing the pulp from the apical end of the root, and found the resistance through the wet walls, after filling the apex, but slightly greater than the total resistance before drying the tip for filling. If time would permit, these same relations should be applied to two and three roots of teeth, and they would explain quite perfectly the clinical data.

While we have these relations fresh in our minds, let us review the observations made from the clinical data. (See page xxx.)

The last two observations are undoubtedly due to the diminished size of the apical foramen, and the increased proportion of organic matter in the tooth substance with age. This matter of the relation of the resistance in a circuit to the relation of two paths in some part of the same circuit, should be clearly understood by the operator before he can give his patient his best services. I would advise every student of cataphoresis to make a study of it, for it is a factor to be considered in almost every cataphoric operation made on the teeth. It can be found in any good work on electricity. A quite thorough discussion of it can be found in the report of the Ohio State Meeting of December, 1896, in the February number of the *Ohio Journal*, or in the February and April numbers of *Cosmos*, by the author. No such condition as obtains in the teeth is found in the medication of other tissues of the body by the same means. And for two reasons: A difference in the nature of the tissue, and a great difference in the nature of the circuit.

Let us now consider the forces at work in the process. Except at infinite dilution of the medicines the electric current will not entirely disturb the internal forces within and between the various mediums, consequently we must consider these as well as the new ones arising from

the presence of the current. First, what are the physical conditions that exist under the circumstances which we are considering?

Physical Conditions in Cataphoresis.

Beginning with the anode we have a conductor of the first class (a metal) in contact with a conductor of the second class (an electrolyte). This electrolyte is a solution of a compound substance which is in contact with another solution which has the same solvent if the medicament is in an aqueous solution, though different substances in solution. This second solution is also an electrolyte and is the contents of the dentinal tubes. The first electrolyte is also in contact with an insoluble porous partition, if you choose to call it such, the matrix of the dentine, which is composed chiefly of insoluble inorganic salts. This porous partition, as also the second solution, is in contact with other solutions of the tissues surrounding the tooth. Besides these we have an organic cell membrane within the interstices of the porous partition.

The forces at work between these various substances, without the presence of an electric current, are those existing between liquids containing different substances in solution, in different concentrations, with or without the same solvent, and those forces arising from potential differences existing between a metal and a liquid and between two liquids.

Taking these up separately we have first the potential difference existing between the metal and the first electrolyte, due to the solution pressure of the ions of that metal and the counter osmotic pressure of the ions of the compounds of that metal, if they exist, in the solution. These factors depend entirely upon the metal forming the anode and the solution. With gold or platinum and the cocaine solution this force would be infinitely slight and would not produce any considerable potential difference.

Osmosis.

Between the electrolytes, viz., the cocaine solution in the cavity and the contents of the tubes we would have the forces existing between all solutions. Of these Osmosis is the chief, and the only one which we need to consider. It is that force exerted by any substance held in solution in its efforts to fill all possible space. Osmosis does not require to take place through a diaphragm or wall of some kind, it takes place in any solution of uneven concentration, and is that force which makes the concentration uniform throughout. If a partition is in the way it will try to go through it, but if that partition is impermeable to that substance, though not to the solvent, it will then pull the solvent through to it. This force is enormous. In fact it is identical with the force that would be exerted by that same substance, in the same space, in the gaseous condition, if the solvent were removed. Time forbids any suggestion as to its relations

to the other forces. In the solutions which we are considering we have certainly different concentrations, and if there is no semipermeable membrane these substances held in solution will, by their efforts to equalize the concentration, diffuse each into the other solution. If there exists a membrane impermeable to them, but not to the solvent, they will try to draw the solvent of the other solution to them. As a matter of fact the cell tissue of these dentinal tubes have in their limiting membranes a membrane semipermeable to many solutions. This would not prevent the cocaine from entering, but would probably prevent some of the substances held in solution forming the contents of the cells, though not all. If all, then the cell would expand to take in water.

Between the cocaine solution and the solid substance of the dentine there would probably be a very slight potential difference, not a thousandth part of a volt, however, arising from the solution pressure of the ions of the latter in the former, forming, as betwen the metal and the first electrolyte, an electrical double layer. This force would be very slight.

Influence of Electric Current.

Let us now consider the forces existing under the same conditions when an electric current is passing through them.

Since an electric current cannot pass through any conductor of the second class except by means of the movement of ponderable matter, we must consider this force.

In every solution the molecules of the dissolved substance are to a greater or less extent dissociated. These dissociation products contain electric changes, either positive or negative, but always the same quantity of each in the solution. During the passage of an electric current these ions are attracted toward their opposite sign, and, at the electrodes, give up their electric charges and combine with it if possible, if not, are liberated to react in the solution or are given off as gas. Exactly the same quantity of ions must be liberated at the two electrodes at the same time, otherwise there would result an accumulation of positive or negative electricity in the solution, which is an impossibility, the detailed reason for which time will not permit.

In all parts of the solution there will be a migration of ions toward their respective attraction, but the velocity of this migration will depend upon this ion itself, and the concentration of the solution, with increased concentration a decrease of velocity, though not of conductivity. If the concentration of the ion gets low around the electrode new ions are formed from the molecules in the solution. At infinite dilution the dissociation is complete. This varies for different substances, but for cocaine hydrochlorate in water is far greater than any solution we would use. Of course the difference of concentration of the particular ion

will produce an osmotic pressure of this particular ion. Owing to the different migration velocities of ions, the amount going each way would not be equivalent at a particular point in cross section *unless* they had the same velocities, for example, K and NH_4; K and Cl. or K and L. have almost identical velocities. These velocities are quite easily determined. Please note this, as I did not make it clear in a recent paper.

In brief, "The quantity of an electrolyte decomposed is directly in proportion to the quantity of electricity which passes through it; or, the rate at which a body is electrolyzed is proportional to the current strength."

If the same current pass through different electrolytes the quantity of each ion evolved is proportional to its chemical equivalent. "The chemical equivalent is the weight of the radical of the ion in terms of the atom of hydrogen, divided by its valency." Which is equivalent to saying that, "The number of electro-chemical equivalents evolved in a given time by the passage of any current through any electrolyte is equal to the number of units of electricity which pass through the electrolyte in the given time."

From this we can determine the exact quantity of cocaine carried into the tooth by electrolysis. The formula for cocaine hydrochlorate is $C_{19}\ H_{27}\ NO_4\ H\ Cl$. The best authorities I have been able to get on this subject say that the Cl. forms the negative ion going to the positive pole, and the balance of the molecule forms the positive ion going to the negative pole. If there is no other substance in solution to help carry the current these must do it. We know the migration velocity of Cl; it is, at infinite dilution, 0.00069 cm. per sec. under a potential gradient of 1 volt per cm. So far as I know the exact migration velocity of the other ion of cocaine hydrochlorate has not been determined until done by Prof. Morley for this paper.* It can be approximately guessed from its size and constitution, though not accurately.

We can easily determine the quantity of the alkaloid that has actually started toward the negative pole, though we cannot absolutely determine just how far any portion of it has advanced without knowing its migration velocity. In order to decompose an exact equivalent of any substance it is necessary to send 96,540 coulombs of electricity through the circuit. This is known as the electro-chemical unit of electricity. To find the electro-chemical equivalent of hydrochlorate of cocaine we divide its molecular weight by its valency, giving us 369 grams decomposed by 96,540 coulombs. Suppose the current to be running for 30 minutes at 0.5 M. A. Then $\frac{369}{96540} \times \frac{1800}{} \times \frac{5}{10000} \times \frac{1000}{} =$ milli-

* Owing to breakage of apparatus and much sickness Prof. Morley's investigations have been delayed and will appear in a subsequent number.

grams of cocaine, hydrochlorate decomposed, equals 3.43. Of this 3.11 milligrams has started toward the negative pole. This is a sufficient quantity to anaesthetize a considerable tissue, and especially in this nascent condition.

What are the other forces existing in this system during the passage of the current? The osmosis of the undissociated molecules has practically not been disturbed. The differences of potential between the electrode and the electrolyte has been changed or increased, as also between the electrolytes, and between the first electrolyte and the matrix of the dentine. This is probably the point of greatest interest of this paper. This we spoke of a few minutes ago as the electrical double sheet. It is produced by ions going off from a substance, the dentine in this case, into the solution by their own solution pressure. The substance they leave becomes negatively charged toward the substance they go to. Equilibrium is only established when the solution pressure of the ions is equaled by the electrostatic force thus set up. This is the electrical double sheet. Suppose a partition of clay, or better, unglazed earthen, with a solution on each side and an electrical current, is passed, what takes place? In most cases a movement toward the negative pole, though not always. Remember the solution is positive towards the substance from whence came these ions, and since the increase of positive charge to the liquid, the theory is that the substance of the porous partition, on account of the unbalanced electric charges, attracts the nearest film of the substance, and in this way drags it through the interstices in the form of a simple current. The measure of the result is determined by the quantity of current and the nature of the solution and partition. This is true electrical endosmose.

Question: To what extent does it occur in the process of cataphoresis as applied to the dental organs? We should say in passing that it is this electrical double sheet and its effect on the surface tension that produces the phenomena which we observe when we place a globule of mercury between the electrodes in a sulphuric acid solution. The extent of this electrical double sheet is determined largely by the specific resistance of the solution, and in fact is in direct proportion to it. The nature and especially the minute structure of the partition have a great deal to do with it.

Experimental Tests for Osmosis and Electrolysis.

An experimental test is the simplest way to make the determination required for the answering of the question just asked. If we select a substance of about the same resistance as the cocaine solutions used, and of very delicate test, we should with great thoroughness be able to come to some conclusions. For this

purpose I have made a great many quantitative tests using as nearly as possible the same conditions as exist in the actual operation. To give an infinitely greater surface of dentine for the porous partition, I placed the solution within the pulp chamber and root canals after hermetically sealing the apical foramen. The teeth themselves were placed through cards of gutta percha, and the cavity perfectly separated from any possible connection with the outside solution, which was distilled water. The first solution used was sodium iodide and tests made frequently by the flame test for the sodium which appeared at the cathode in about ten minutes. Various concentrations and lengths of time were given and the solutions very carefully tested for iodine, and even after two hours none could be found. But the question arose, did any of the sodium go through, or did it come out of the tooth? To obviate this question a substance was selected that did not exist in the tooth, namely, lithium, and which has a very delicate test. Lithium iodide was used in many cases, in every one of which the lithium was more or less pronounced in accordance with the time. In 30 minutes it was very marked, and in 2 hours profuse. In no case could a trace of iodine be found. I had Prof. Morley, ex-president of the American Association for the Advancement of Science, repeat the tests, and he said he knew there was not the one ten-thousandth part of a gram of iodine came through, for he could not find a trace. He made a quantitative test. He detected the lithium by means of the spectroscope, and was unqualified in his assertion that the lithium got there by electrolysis. In fact, it arrived there at the time calculated from its migration velocity by electrolysis.

The question now arises, why should we not be assisted by this force of electric endosmose? For several reasons. The dentine contains tubes to be sure, but they are not open so a current can flow through them. If the solution passed through them it would have to penetrate the limiting membranes of the cell, which is a slow process. It might be suggested that it could go between the cells and tube walls, but the total cross sectional area of the intercellular spaces exposed in a cavity would be extremely small. Another great factor is the specific resistance of the solution which does not favor it.

As a matter of fact the phenomena of electrical endosmose are very often chiefly the result of the forces of osmosis acting naturally upon the products of electrolysis, or of cycical chemical processes in connection with electrolysis, as for example, the particles of carbon or many other substances in a solution. The carbon particles are insoluble, of course, but they are conductors of the first class, and when the current is passing it goes through them because they have less resistance than the solution.

But where a current is passing from the surface of a conductor of the first class to a conductor of the second class, there must be either of two things, a liberation of the ion as gas, or it must unite with the electrode, or in a compound reaction with the substances of the solution. In this way the carbon particles enter into a compound molecule which later is broken up by dissociation, the carbon becoming a part of a positive ion, and is hurried along toward the negative pole. On its way it meets a positive ion for which it has a greater affinity than the electric charge carrying it, and it again forms a new compound, which if insoluble is left suspended in the solution. In this ionic form it could penetrate cell tissue or anything else that contained an electrolyte and be deposited.

Gentlemen, I regret the length of this paper, for I had hoped to have time to make some practical conclusions. This is really just the preface to the subject. In behalf of the needs and absolute requirements for the most successful application of this process, I appeal to the manufacturers for better apparatus. There is not delicacy or accuracy enough in our milliampere meters. We must have them reading to 1 milliampere in hundredths. Mine reads to hundredths of millionths of amperes; hundredths of thousandths of amperes will do for practical work. The controllers are yet far from what the sensitiveness of some teeth, to pulsations of current, demand.

Mouth-Breathing—Cause and Effect.

By GUSTAVUS NORTH, A.M., D.D.S., Springville, Iowa.

Read before the Northern Iowa Dental Society at Mason City, September, 1897.

The subject which I will present to you has, in my opinion, not received the attention that it should. Mouth-breathing is not simply a habit, but the child is forced to breathe through the mouth on account of some malformation or foreign growth.

Mouth-breathing is caused by some obstruction in the nose or in the naso-pharynx. The obstruction in the nose may depend upon a congenital narrowing of the passage, or from deformed bony walls.

In some cases the septum becomes thickened or deviated, and in other cases we find only the soft parts cause the obstruction.

I will not attempt to give treatment, but simply quote what a leading specialist says of these deformities.

"Is it right to let the patient go through life with loss of hearing, and the deformities of face and chest, and with other inconveniences and mouth-breathing, etc., when a simple operation will give entire relief—an operation devoid of danger?"

Mouth-breathing in childhood has a tendency to cause malformation of the superior maxilla, which, at this period, is very soft and yielding, and the pressure of the lips and cheeks upon the maxilla and teeth will soon cause malformation of the dental arch and a V-shaped form will be developed.

Necessity for Nasal Respiration.

Nature intended the nose as a preparatory compartment to respiration. Inspired air is freed from dust and germs, receives its proper amount of moisture, and is raised or lowered to the proper temperature by passing through the nose. Even if the nasal cavities are in a normal condition, nasal respiration cannot take place if the naso-pharynx is obstructed. The muscles of the growing child become distorted by constantly keeping the mouth open day and night.

The action of these distorted muscles upon the soft and yielding bones of the child's face, together with the absence of admission of air to the accessory nasal cavities—the frontal, sphenoidal, ethmoidal and maxillaries—causes a deficient development of these sinuses, giving a flat appearance to the cheek bones, producing a peculiar physiognomy characterized by the open mouth, a vacant stare, and an almost idiotic expression of countenance.

The hanging lower jaw and constant mouth-breathing, together with deficient development of the bones constituting the nasal septum, and the pressure of the lips and cheeks upon the teeth and maxilla, develops a high arch and also a narrow lower jaw with protusion of the front teeth; this is usually associated with long continued and excessive adenoid vegetation.

In infants the first symptoms to attract attention are, as a rule, "hard" breathing or snoring during sleep. In older children, it is the dull voice and deafness which generally attracts attention.

Irregularity of the teeth is oftentimes caused by neglecting the treatment of the diseases of the throat and nose, which should come under the care of a specialist.

SOCIETY DISCUSSIONS

Second District Dental Society.

January Meeting.

A regular meeting of the Second District Dental Society of the State of New York was held on Monday evening, January 10, 1898, at the "Argyle," No. 153 Pierrepont street, Brooklyn, N. Y., with the President, Dr. O. E. Houghton, in the chair.

In opening the meeting the President said:

"Gentlemen, this meeting, our joint meeting, we have always set apart to invite our brethren from New York, and our brother hornets from New Jersey, to be with us. I assure you that those of you who have come from the Borough of Manhattan, and the hornets from New Jersey, are heartily welcome and we hope to see you often.

"Tonight, we have a treat in store for us. The subject of discussion is the 'Foundation Principles of Dental Cataphoresis.' We have all been taught to believe that electricity was the thing to use if we wanted anything done quickly. However, electricity, as manifested in cataphoresis, is as slow as cold molasses, as most of us have found out, but perhaps we will have some enlightenment on how cataphoresis can be made more rapid.

"The gentleman who will read a paper to us has come many miles to be with us, and we know him to be an authority. I take pleasure in presenting to you, the essayist of the evening, Dr. W. A. Price, of Cleveland, Ohio."

Dr. Price read the paper published in this issue, and the following discussion ensued:

Dr. Wm. J. Morton. I congratulate Dr. Price upon the character of his paper. If one is looking for excitement, it might be called dry, but if one is looking for information, it is full of that; and if one is looking for deductions on which to work, then he has some here that will last for many a long month.

One of the interesting points was that about the time limit. The time limit he found to depend upon the direction which the current took as it flowed through the tooth. The deduction to be derived from this, is that the current also goes in large ratio by the root walls of the tooth. In other words, that there are two directions of flow rather than one, and that one must be on guard to determine through which the current is passing. That point has never before been brought out, and is derived from his mathematical measurements.

In my mind even that single fact has bearings that we do not suspect, and one of these bearings is that not alone are we interested in making the dentine of the tooth numb in order that we may work without pain, but that we may properly treat the tooth when diseased.

If you want to treat the tooth with chloride of zinc, or some other drug, it is interesting to know from these measurements that that drug will permeate and diffuse itself not alone through the apical foramen, but also through the lateral walls. There is a confidence that you may sterilize a tooth, and that you may do other things with it besides anæsthetizing it.

Another interesting point is that the time limit from these experiments may be due to heat as well as to some particular effect upon nerve fibres. The degree of heat that might be generated at the apex seemed to me most extreme, and if the measurements are correct it shows that in dealing with tooth structure heat must certainly be taken into account. The degree of heat that is produced in any ordinary drilling is not considered, and I have never supposed that the heat element was so important a consideration in the treatment of dentine. There is a reservation, though, that in the calculations made by Dr. Price, a large part of the resistance lies in the skin, and the resistance therefore would be reduced. That, at least, is the way I should understand it.

The paper makes a differentiation between cataphoric phenomena, as to whether they are electrolytic or of some other nature.

In a previous paper, Dr. Price claimed that all the phenomena of cataphoresis were due to electrolysis, and in tonight's paper we have some additional considerations that relate to the porous septum, independent of the phenomena of electrolysis.

Now you would not think it made any difference, to you or to me, whether it is electrolysis or an electro-static movement, or a mechanical movement; but you noted some of the deductions that Dr. Price drew, and you recognized their importance. For instance, he claimed that if it were by electrolysis—if the substance, hydrochlorate of cocaine, were decomposed into its ions—and an individual ion wormed its way into

the dentine, from the positive to the negative pole, it was important not to mix up solutions, not to have different kinds, but to use only simple solutions. Well, now, if the fact were that it is electrolysis, then of course the advice is good, but shall we jump at conclusions of that kind and claim that it is solely electrolysis? That part of the subject interests me somewhat. For instance, I have professed on previous occasions that it was important to mix guaiacol with the solution of cocaine, and if it is electrolysis what is the use of the guaiacol? I claim that guaiacol has a tremendous importance. I do not pretend there are no objections to it.

In practice on the skin, five years ago, I was in the habit of using an electrode one inch in diameter. I used a 10 per cent. aqueous solution of cocaine. It took 15 milliamperes of current, and it took 10 minutes to get a numbing effect upon the skin. Now there is a 10 per cent. solution, 15 milliamperes, and 10 minutes of time. By taking an 8 per cent. guaiacol solution of cocaine I can with 2 milliamperes of current, in 2 minutes, get a more perfect anæsthesia; and that I do all the time.

Thus you see there is a difference upon the skin as above outlined, and I would say there is the same difference in the dentine, therefore, before we doom guaiacol I must be given some reason why a similar acceleration does not take place in the dentine, and I would like to have some proof of that.

I believe that we cannot explain the whole subject by electrolysis; I do not think we can explain it wholly by decimal measurements as in this paper. Here are these interesting experiments; they are conclusive so far as they go and they are beautiful. We know that the ions have different facilities of movements. I do not know how many of us can calculate them. It is interesting to know that they can be calculated and to know how deep they will go, but these data are not particularly essential to an operator's work.

Now it is the dentine itself that feels the difference between ordinary electrolysis and cataphoresis. In the sense that I mean, the porous septum itself becomes an electro-static center and the ion is a similar electro-static center, and the porous partition being structural, directs to itself the ion of the opposite name.

The distinction between the two is this: By electrolysis the drug is decomposed, and you would administer an alkaloid of cocaine. If electrolysis does not take place you administer hydrochlorate of cocaine.

The point is, if it is not decomposed you carry the molecule in, and if it is, you carry the ion in. I do not know of any one authority today that claims that what we know as cataphoresis is electrolysis. There may be such authorities—perhaps Dr. Price will tell us of some—who claim that this directive motion of the current is electrolysis.

If we take a ball of clay and wet it, and pass two needles into it, the water will run out at the negative only. There is simply a movement of a fluid. Electro-physics is full of examples of that kind, where there is a directive movement from the positive to the negative pole, or vice versa, without having any electrolysis, except such as is essential—in fact, is the flow of the current. The only question is, what does the moving? What is this force that makes cocaine go into dentine? Is it the electrolysis or is it some further property of the current? Is it the molecules or the ions that are driven in?

What Dr. Price has said is very nice, but at the same time I do not believe that cataphoresis is altogether electrolysis.

Perhaps some think it is of no importance, but when it comes to a question of the nature of the solution, it will be found that it is of great importance. The great fact I would lay stress upon in this description of phenomena, is that the process takes place at the expense of the porous partition. Now the porous partition is dentine, and as you want to know what is going on in dentine when you are treating it, it is well to keep in mind that you have not alone the electricity for your pushing force, but that you also have a porous septum, whose relation to these different movements must be studied, and I think one of the gains to be derived from experimentation will be the knowledge of the nature of cataphoric applications upon the septum, that is to say, upon the dentine itself.

Dr. Gillette. I want to express my admiration for the colossal labors in Dr. Price's paper. My own little work of this kind, a couple of years ago, leads me to know something of the time he took to prepare it. I have realized for a year at least, that what we thought and what we seemed so set about, in the earlier work concerning the character of the process, was wrong—that electrolysis was a factor, or that a modified electrolysis was a factor. I think I stand somewhat with Dr. Morton tonight, in that I do not fully accept electrolysis as the sole factor in the case. The point that Dr. Morton raised is one that has been puzzling me since Dr. Price first advanced the theory that electrolysis is the main agent.

One point that I would like to ask Dr. Price to answer is, how he would explain the fact that in a very large proportion of cases (it seems to me *all* the cases, but I do not pretend to put forward any such theory) we find a pain limit at quite a low point, and in a very short time—a time much too short for the cocaine to reach the foramen—we are able to increase the current largely without unduly increasing the pain. It seems to me that this is an objection to the theory that Dr. Price advances.

Dr. M. L. Rhein. I believe that Dr. Morton in speaking of the dentine as the porous septum, struck the key-note of this whole matter. Conditions that this porous septum presents, vary with each tooth, and I have no doubt, when I come to consider the subject from a logical standpoint, that the porous septum may be of such a nature as to compel electrolysis in certain cases, while in others it may be of such a nature as to enable cataphoresis to proceed in a purely mechanical line, if I may use such an expression.

Dentine Softened by Cataphoresis. I have noticed that with one of the old forms of batteries, where they used the ordinary bladder at the start, they soon give up this bladder because it becomes so soft as to be valueless after a time. I have noticed that an action of this kind also takes place on the dentine. To my knowledge, up to the present time, no attention has been brought to this point, that is to say, a deterioration of the dentine itself. For a long time I labored under the delusion, that I gained a great deal of time after my tooth was anesthetized, by the rapidity with which I could proceed with the excavation of the cavity. During the last month, in the course of excavating that class of teeth which, notwithstanding Professor Black, we know are very hard to drill, and where I had to cut through enamel for certain purposes, I began to be impressed with the fact that my former deduction was erroneous, and that a great deal of this rapidity of excavating which followed the anesthetizing of the tooth was due to a softening of the tooth substance, following the cataphoric anæsthesia of the tooth. Now I do not know whether this has been publicly presented before tonight, but I have noted this phenomena carefully within the last few weeks. In these teeth of very hard character, immediately after anesthetizing, I would be able to proceed with my burring quite rapidly. Suddenly it would cease to become so rapid, and very shortly afterwards this particular patient would manifest returning signs of sensation, which upon the re-application of the cocaine was followed by the same easy ability to bur the remaining portion of the dentine.

In thinking over this matter, if my deductions are correct, and I think they will be found to be so on careful investigation, this matter is presented to me in a double-sided aspect. The question arises, if we are softening the dentine in this way, if we are decomposing our porous membrane, as the old bladder was decomposed and softened in the old batteries, are we not possibly doing some permanent injury to the tooth, and is it not necessary that we should use cataphoresis with such care as not to soften any more of this membrane than we intend to remove

permanently, not extending the softening process to a portion of the tooth substance that we intend to retain? I cannot conceive of any way in which this can become so hard as it was before this deterioration has taken place? This is the one contribution I have to make to the subject, and I would like to hear from Dr. Price whether this point has come up in his experience.

Dr. Ottolengui. The paper is full of figures and mathematical calculations. I have been making some mathematical calculations about this paper, and I have figured out that the total of labor and thought exerted by Dr. Price to produce this paper, is just about equal to the sum of all the labor and thought expended by the authors of all the papers in about six months' issue of an ordinary dental magazine.

Cocaine Dosage in Cataphoretic Anæsthesia.

I have to admit that I am not an electrician, and that I am not an electric physician, and therefore I am quite ignorant on this whole subject; neverthelesss, even an ignoramus sometimes empirically reaches the truth, and I am delighted to find that I have reached one truth which others had not quite agreed upon, and that is this: I have heard quite considerably discussed the necessity of knowing how much cocaine we were using, in case we might get into legal controversies with our patients. Now I did not know whether it made any difference how much cocaine was put in a tooth. I thought, in my ignorance, that the quantity of cocaine on the cotton was of less consequence than the quantity of cotton. That is to say, whereas the cotton might interfere with the passage of the cocaine, the quantity of the cocaine was of no consequence, the cotton holding it merely as a reservoir, and that the dose of cocaine used would not be what was placed in the cavity but only the quantity taken in by the current.

Dr. Price. Less than that, you have left out the decimal.

Dr. Ottolengui. I did not see the point, that is the decimal point; that is much better. Now all we need to do in the future, if we are asked by the lawyers to state how much cocaine we may have used, is to say if anæsthesia was reached, "three milligrammes," and if not, "less than three milligrammes." In two or three months you will have this in the literature to support you.

Dr. Pease. I would like to ask a question. In a recent case of septicemia, it was claimed that the poisoning was produced by the attempt to sterilize a septic tooth, the septic matter being carried into the tissues from the porous partitions which were diseased. The patient came near losing his life. Could this be true?

(In further explanation of his views on endosmosis, Dr. Price spoke at some length, illustrating by some very pretty experiments with test tubes and the electric current passed through their liquid contents. As these remarks would be unintelligible without the experiments they are omitted.)

Dr. Price. In answer to Dr. Rhein's question, I may say I have made some quite elaborate experiments to determine by electrolysis some of the contents of the cells. Suppose we are disassociating with sulphuric acid in the cavity, or a sulphate. We have hydrogen ions coming to the surface and they will not necessarily be liberated. As hydrogen ions they will probably react on the solution and form an acid at that point. In fact I can show you right here in an alkaline solution, an acid reaction while just a few millimeters from it there is a positive alkaline reaction.

Dr. Freeman. I think Dr. Rhein states that he finds disintegration and that there is a slight softening of the dentine, and that afterwards the dentine is very hard, and he cannot drill so rapidly.

Dr. Price. I would say that the number of pulsations that would pass through in the bladder, would probably be lessened before there would be disintegration. The inference is absurd.

Dr. Rhein. Have you not noticed clinically that the dentine cuts easier after the anæsthetic has rendered the tooth numb?

Dr. Price. Probably I did not observe. I use very sharp burs always. I think the fact that it did not hurt would bring a new fact next as to the quality of cocaine. Since the ion velocity is greater in the dilute solution, it would be an advantage not to use an unreasonably diluted solution. I think where the rapidity of the ion would be greater we would be justified in not using over 10 per cent. of cocaine. If we used 50 per cent. saturated solution, the rate of travel of that ion would not be so great. If we used too dilute solution we might run out of cocaine.

Resistance of Pure Water. Let me remark that absolutely pure water is almost perfectly disassociated; in other words, its resistance is very high. One milligramme, that would be three times the thickness of your thumb nail, of distilled water that was perfectly pure, has as much resistance as a copper wire reaching 1,000 times around the world.

The last question was regarding the movement of septics. By electrolysis of a septic we would have, undoubtedly, a migration of those

septic products disassociated, carried toward the negative pole, but unless they found that same ion somewhere else, that molecule would not produce, in my mind, any trouble. Was there a germicide used?

Dr. Pease. I am not positive that there was.

Dr. Morton. Would it not be important to ask what the septic matter was? If bacteria, it is hardly plausible that an animal of that size would be moved along. That I think is important to know.

Dr. Pease. The case was not mine, but the report came to me, and certain parties who might have caused trouble claimed that it was due to the cataphoric application, and if the patient himself had known it as others believed it to be, he would have commenced action.

Dr. Price. I do not think that it is possible, and I am so sure of it that if I was on the witness stand I would almost swear that it was absurd.

Office and Laboratory

Dental Office of Dr. E. S. Fuller, Piqua, O.

In presenting an arrangement of my office for your consideration, I fully realize its incompleteness compared with those previously illustrated, but perhaps it may suggest something of value to some one with

limited means who desires to fit up an office with as little expense as possible, and yet, have it cosy and inviting.

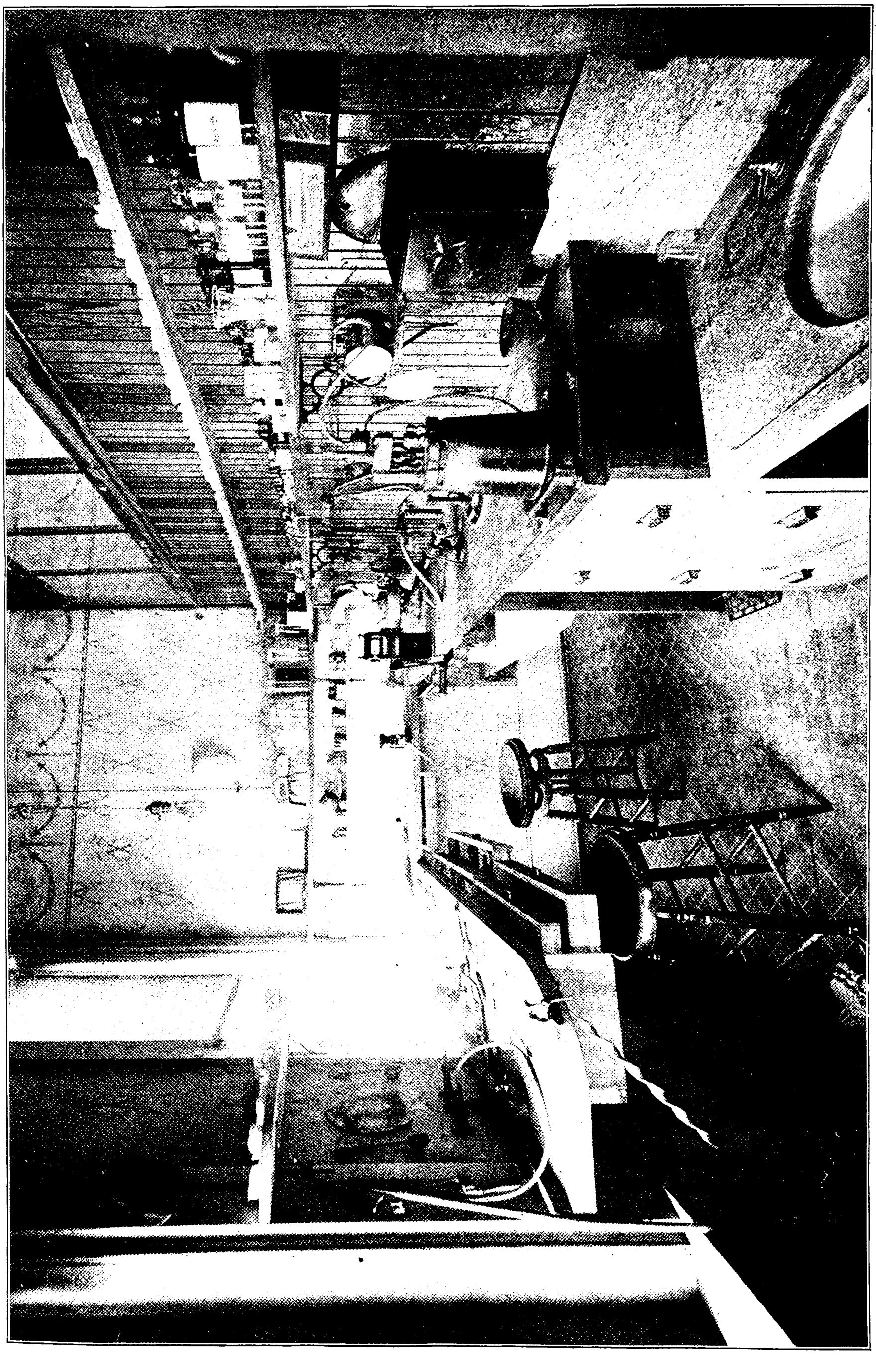
The room is 18 by 24 feet and is divided by partitions, into a waiting-room, operating-room and laboratory. Each apartment has two windows looking north and east. The waiting-room is carpeted, heated by

a gas stove and lighted by a gas lamp. A partition conceals the entrance door from the view of patients in the room, thus allowing it to be used as a private exit or entrance, if desired. A draw curtain separates the waiting-room from the operating room, which is kept closed while operating.

The chair is placed between two windows, a cabinet stands at the right and a desk at the left of it. At the foot of the chair is a small gas stove, which is occasionally needed in cold weather.

The operating-room and laboratory windows are provided with short dotted Swiss sash curtains. These offer little obstruction to the light and only slightly interfere with the view from the inside. A single incandescent lamp is used, if needed, and may be drawn out of the way during the day. Linoleum covers the floor of these two apartments.

The laboratory has benches on three sides. The one on the left will be extended beyond the window and a curtain will take the place of the swinging door. A washstand is in the right hand corner of the room, making it convenient to the chair. Near it are three large drawers; the



two lower for odds and ends and the upper one for waste plaster. An arched hole is cut in the bench over it, the plain edge being beveled inward, which leaves a sharp edge upon which to clean plaster spatulas, etc. It is easily kept clean, as the plaster has little or no surface upon which to adhere. The vulcanizer stand is placed near the door and serves a triple purpose, being used as a water heater and as a soldering stand, by using the bowl of the Lewis case heater which fits it. Fletcher's Safety Bunsen burner furnishes the heat. The time regulator also does double duty, a small bell being secured to the clock in a position to be struck by the lever when it disengages with the screw threads, this being a signal that a case in the electric furnace is nearing its fusing point.

The foot power for the lathe is improvised from various parts of old sewing machines. A large pulley balance wheel operates a small pulley on a shaft above. A second pulley, larger connecting with the lathe head. It gives a high rate of speed, is steady and decidedly inexpensive. I would prefer an electric motor, however. On a shelf beneath the bench are placed plaster cans, sand, etc. The rolls and large vise I find almost indispensable. The bench on the left when completed, will be spaced for crown and bridge work, nearest the entrance, regulating work in the middle and porcelain at the end. On the narrow shelves at the side and end are placed laboratory bottles, models, etc., and the upper one at the end supports a plating outfit and a Downie continuous gum furnace.

EDITORIAL

Address Manuscript and Exchanges to the Editor, 115 Madison Ave., New York.

Matter Designed for a specified issue should be received by the tenth of the previous month—preferably typewritten.

Address Subscriptions and Business Letters to the Publishers, 115 W. 42d St., New York.

There Are None So Blind As Those That Will Not See.

In the March issue of the *Dental Digest* appears another editorial in which the editor of that magazine arrays himself against the Appeal to Congress in the matter of dental patents. A careful reading of this editorial compels the belief that the editor either does not comprehend the movement, or else does not wish to do so.

In Items of Interest for 1897 an editorial introduced this subject of asking Congress to amend the patent laws. On page 205 may be found the following words:

"It is, therefore, a short-sighted policy and opposed to the welfare of the professional body, to cast ethical reflections upon the medical or dental inventor who takes a patent upon an article of manufacture, which, when produced, is offered to all at a uniform price."

On page 208 this paragraph occurs:

"In summing up these arguments let us admit the right of professional men to take copyright; let us encourage the brighter minds to invent instruments and appliances, and to cover them with patents; but let us ask our government to guard us in the future from those human harpies who do not hesitate to prey upon the suffering of their fellows; who are willing to sit in idle luxury which they purchase with the tribute extorted from the pangs of human pain."

The Correspondent's Report to the New York State Dental Society was published in Items of Interest, January 1898, and on page 9 are these words:

"If a man invent a tool, or implement or any article which may be manufactured and sold alike to all, let him obtain a patent."

In the same issue was an editorial announcing that petitions had

been printed which were to be signed by members of the profession. On page 61 is this statement:

"Whatever may be honestly invented, and subsequently manufactured and sold, is a legitimate subject of patent."

Is there any ambiguity about this language? Is it not made clear in every instance that the dentists have no contest with those who invent articles which may be manufactured, nor with those who manufacture articles which have been invented? Yet the editor of the *Digest* tells his readers that the editor of ITEMS OF INTEREST,

"intended that dentists as a class should petition Congress to restrain the granting of any patent upon any mechanism or procedure of any description employed in the practice of their profession."

In the next paragraph he alludes to the petition as a petition "to prevent the granting of any patents relating to mechanical appliances," etc., etc.

Argument in refutation is not necessary. Any fair-minded dentist with even a moderate knowledge of the English language can read the above quotations from the pages of this magazine and judge for himself whether the editor of the *Digest* has correctly stated the facts.

But a worse misrepresentation is made later in the same editorial. The editor of the *Digest* refers to a suit pending between his Dental Supply Company and the owners of a patented broach, and then says:

"According to the editor of ITEMS OF INTEREST this barbed broach patent is granted upon 'a method of treating human disease,' as the article is used in the extraction of devitalized pulp and for scraping and cleaning the decayed walls of pulp canal. Of course such a patent for this reason alone, irrespective of its validity, would be condemned by said editor. He says in his editorials, 'Treatment of the pulp should not be patented, yet such patents exist.'"

Such a paragraph excites astonishment. The writer of it states that the editor of this magazine would consider a patent upon a broach, to be a patent upon a method of treating disease. This is a misstatement of the truth, and a misinterpretation of all that has appeared in these pages on this subject, as is abundantly evident from the quotations given above. The editor of the *Digest* is entirely wrong. The editor of this magazine would not consider a patent on a broach a patent on a method of treatment. A broach is an *instrument*, an article of manufacture; it is not, and cannot, by the most imaginative mind be looked upon as a

method. It is very true that objection was raised to patents on *methods* of treating pulps, but it has never been argued that patents on *instruments* for treating pulps are unjust. A patent on a *method* of treating pulps was granted to C. M. Richmond and, as already stated, "covers a method of cutting grooves on opposite sides of a living tooth and then removing the natural crown with incising forceps. The pulp is then removed by driving a sharpened orangewood stick into the pulp canal, which is later filled with a similar orangewood stick."

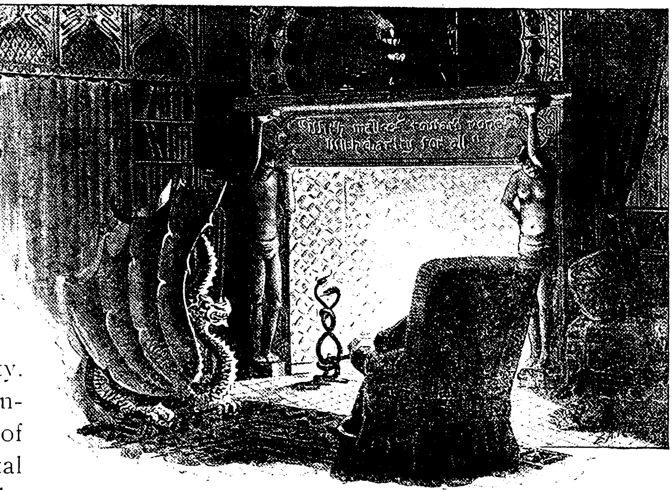
It should be noted here that the patent is not upon the incising forceps used, nor upon the sharpened orangewood stick; what the patent protected (whilst in force) was: first, the cutting of two grooves on opposite sides of a tooth; second, snapping the crown off with forceps; third, sharpening a piece of orangewood; fourth, driving this sharp stick into the living pulp; and lastly, filling the canal with a stick.

This was strictly a method of treatment. This is the particular patent meant when it was said that "treatment of the pulp should not be patented." This the editor of the *Digest* knew, or should have known, and it is difficult to find any just excuse for his misrepresentations. Is there any?

Present Status of the Appeal.

During the last month the Senate Committee on Patents appointed a day upon which a hearing was granted in the matter of the appeal for an amendment of the patent laws. Dr. Ottolengui visited Washington, and appeared before the committee attended by counsel. A general review of the situation was presented, and all the queries of the Senators answered. A brief was filed, together with letters from the presidents of the Consolidated and the S. S. White Dental Manufacturing Co., which recite that the bill as drawn has their approval, and in no manner militates against the interests of manufacturers. Our petition, with nearly three thousand signatures was also delivered. From reliable sources it may be announced that the Senate Committee will not antagonize the bill, but in consequence of the war, it has not been deemed advisable to press the matter yet in the House of Representatives.

The Editor's Corner.



In this issue we offer our readers a novelty. An illustrated interview with one of our highest dental authorities. In the current literature of 1897 the most important paper published was from the pen of Dr. J. Leon Williams. In that paper he announced the result of years of microscopic research and proved beyond further quibbling that tooth decay is of bacterial origin. Many of the scientists and students of the dental world unquestionably read and enjoyed that paper; but undoubtedly also a much greater number "skipped" the pages which it occupied, deterred by the very micro-photographs which were the foundation of the whole argument. In other words to these men, who love to call themselves practical the illustrations indicated at a glance that the paper was scientific and to such men there is little, if any, relation between the terms scientific and practical. Yet it is certain that this very paper was the most "practical" contribution to our literature published in years.

Practical Value of Scientific Research.

Recognizing, however, that while Dr. Williams's work is both scientific and practical, there are very many who failed to realize this, it seemed not a bad idea to obtain for our readers some of the "practical" results of Dr. Williams's researches and to publish it in such a form that even the most ultra practical man would recognize the value of knowledge in relation to the organs upon which he works.

A number of questions, therefore, were formulated and sent to Dr. Williams with a request for his views as to their proper solution. Some of these are published in this number, with the doctor's replies; others will appear later.

The most practical man admits that cataphoresis is a boon. But he wishes to be enabled to visit his dental depot and purchase a cataphoresis machine which, when taken to his office, will enable him to control all cases of sensitive dentine, with a minimum expenditure on his part of time, labor, and knowledge. As to knowledge he has no particular desire to know *how* it works, so long as it *does* work. That is his idea of a practical apparatus and method.

But this gentleman is not destined to be satisfied. The "practical" manufacturer will give the profession a perfect cataphoric outfit, only after the "practical" dentists have gained sufficient knowledge to know what is required. Even after the mere mechanism of cataphoresis shall have been perfected, the "practical" dentist will discover that unless he understands something of electrics, something of chemics, and quite a good deal more than he does now of the causes of tooth sensitiveness, his practically perfect outfit will fail in many cases. These failures will ensue because the "practical" dentist is not scientific enough to understand the obstacles which prevent his success in special cases.

Time was (not long ago, and occasionally now we hear the phrase) when the contents of the root canal was always called "the nerve." Of course, this indicated that it was thought that all the soft tissue in the canal was nerve tissue. Then we learned the falsity of this and since then we (that is some of us) speak of "the pulp." But many know as little about this "pulp" as they did about the "nerve."

The microscope shows that the dental pulp is traversed by a complicated system of blood vessels and nerves. In other regions of the body the courses of vessels and nerves are often parallel, and intense nerve pains are produced by improper passage of the blood through the vessels thus producing pressure against the adjacent nerve. The ordinary bilious headache, with its accompaniment of throbbing temples, is a common example. How easily then may we understand the throbbing toothache, caused by a congestion of the vessels of the pulp, which is circumscribed within the unyielding walls of the tooth canal?

Thus in sensitiveness, which means painful response, in teeth, it is necessarily true that we have to consider the blood vessels as well as the nerves of the pulp. The question dealing with this subject was formulated with the especial view of bringing forth knowledge which might lead to a better and more practical use of cataphoresis, by furnishing a better knowledge of the causes of that pain which we combat.

Oddly enough it happens that coincidently we publish a paper by Dr. Price, on the subject of cataphoresis. Probably because there are a number of pages of tabulated matter, the practical dentist may skip much or all of this. If he does he will be less practical than he might

become with the knowledge to be gleaned by a careful study of these very tables. Think of the hours, and days, and weeks, occupied by Dr. Price in obtaining the data for these tables! Remember that these tables result from practical work which they record really tersely. And then decide whether you can afford, Dr. Practical, to skip any of the valuable material offered in these two magnificent papers.

In Dr. Price's paper the point of chief interest to the "practical" man and to the scientific student, is his statement in connection with the passage of a part of the current, through the tooth laterally instead of through the apex. Dr. Price believes that such a distribution of the current often occurs and lengthens the time required in producing anæsthesia. But his deductions cannot be finally adopted until we more fully comprehend the relation between the nerves of the pulp, and the nerves of the pericementum. With this statement the matter may rest until we have heard all that Dr. Williams and others have to tell us.

Correction of Our Dental Law Map.

Almost immediately after the publication of the synoptical map of dental laws which appeared in our March issue, we began to receive letters from Texas by every mail. Dentists in all parts of that State kindly wrote to inform us that Texas had no "blue law." Finally one gentleman wrote on stationery belonging to the county sheriff, indicating that he had gone to headquarters to obtain official information. He begs us to announce that Texas should have been "yellow" on the map. The correction is gladly recorded. It would have been much better, however, if our Texas friends had been as willing to write letters before the map was published, as after. Many, many letters were sent all over the country asking dentists to forward copies of the dental laws to this office. Letters of this character went to five men in Texas, without result. Texas was made "blue" on the map upon information furnished by two members of the Board of Dental Examiners, in response to inquiries by Dr. Meeker, the secretary of the National Association of Examiners. It is odd that these gentlemen, whose duty it is to inforce the law should not have properly comprehended it.

Good Method of Making Dies for Crowns.

Dr. A. H. Davis, of Nashville, Tenn., a student in the dental college, offers the following suggestion for making "A counter-die for a die of Mellotte's metal, when making a central lateral or cuspid open-face crown." The die being made, he proceeds thus: "Burnish over the die a piece of pure tin, 32 gauge, and immerse in ice water for few minutes. Wipe dry, and pour the counter with Mellotte's metal as cool as it will flow, and immerse in ice water again, when it will be found that the two will separate readily. The tin comes out uninjured

as it fuses at a higher degree than the die metal. This piece of tin gives the pattern to be followed in cutting out the gold plate, and the space which it occupied between the two parts of the die, makes it possible to swage the gold without fear of tearing."

It would seem from the above that the immersion in ice water is intended to avoid adhesion between the die and counter die, when the latter is poured. A simpler and safer method of making die and counter of the same metal is to paint the surface of the metal die with a thin coat of chalk and water (by chalk is meant preferably what is sold by grocers as "whiting"). The blast from the blow pipe quickly dries this, leaving an even coat of chalk over the die. The counter may be poured reasonably hot, and the parts separate readily.

A Dental Dead Beat in Illinois.

Dr. I. A. Lumpkin, of Mattoon, Illinois, desires to warn the profession in that State against an imposter. He writes as follows: "About a week ago a man came to our office, who represented himself to be a Frenchman from Paris, France. He spoke quite brokenly and laughed at nearly everything he said. He said he was out of money and asked us for $3.00 to take him to Kankakee, Ill., where he said he had a position in a dental office. We advanced him the money, which he was to return the next day, but as he failed to send it, we wrote to Kankakee only to find that he had come from there, here, after trying to get help from the dentists there. We regard him as an imposter and think he should be advertised to save others from being robbed as we were. He gave his name as Dr. Frank Sourle, Rue la Martel 14, Paris, France."

Donations for the National Dental Museum.

A number of valuable specimens have been received in response to our request for donations to the museum. These will be properly acknowledged in our next issue. In the meanwhile we again urge the profession to be more liberal in this matter. It is for the common good of all that specimens should be in one great collection, rather than to be scattered about the country in remote corners of cabinet drawers. The specimens thus far received are numerous and of great interest, but it is sad to relate that they have all come from but three men. Have the others of the profession nothing to give?

SOCIETY ANNOUNCEMENTS

New York State Dental Society.

The thirtieth annual meeting of the Dental Society of the State of New York will be held in Albany, May 11 and 12, at which time the following programme will be presented:

President's Annual Address,
H. J. Burkhart, D.D.S.

Report of the Correspondent, "Prosthetic Dentistry,"
R. Ottolengui, M.D.S.

Report of Committee on Practice,
L. C. Le Roy, D.D.S.

"Ignorance in Dentistry, a Source of Misery and Poverty,"
E. A. Schillinger, D.D.S., Dolton, Mass.

"Removable Bridge, Showing Some Novel Features,"
S. S. Stowell, D.D.S., Pittsfield, Mass.

"The Histology of Cementum, Normal and Otherwise,"
I. Norman Broomell, D.D.S., Philadelphia, Pa.

"Leucoplakia,"
J. S. Marshall, M.D., D.D.S., Chicago, Ill.

"Studies of Maxillary Bones, No. 2,"
M. H. Cryer, M.D., D.D.S., Philadelphia, Pa.

"The Toxic Effect of Cocaine, Induced through Cataphoresis Applied to a Pulp Preparatory to its Removal,"
W. W. Foster, M.D., D.D.S., Baltimore, Md.

A meeting of the Eastern Branch of the National Dental Association is called for 2 o'clock on the afternoon of May 12 for organization, which will bring together a large number of the leading men of the profession from New England, New York, New Jersey, Pennsylvania, Ohio, Indiana, Michigan, and Ontario, Canada. Railway rates of one fare and a third to Albany and return have been secured on the certificate plan; also reduced rates at the Kenmore and Stanwix Hall.

There will be a full line of dental exhibits from all the leading manufacturers of the country.

A cordial invitation is extended to members of the profession of this and other States to attend the meeting and to participate in the discussions of the various topics.

CHAS. S. BUTLER, Secretary,
H. J. BURKHART, President. Buffalo, N. Y.

Delegates to the National Association.

The following sections of the by-laws of the National Dental Association relate to the appointment and qualifications of delegates:

"Article III. Section 3. All delegate members shall be practitioners of dentistry. They shall be received only from permanently organized State dental societies. They shall be elected by ballot at some regular meeting of their society, and shall be members who have done meritorious work for the profession; but no person shall be received as a delegate who is in arrears for dues to this Association."

Also: "Article IV. Section 1. Each State society may send one for every ten of its active members, as delegates to this Association for one year, upon complying with the requirements of its Constitution; but no society shall be entitled to representation that does not adopt or substantially recognize the Code of Ethics of this Association."

The fact that the *American* Dental Association received delegates from both local and State societies, renders it necessary to call attention to the fact that delegates to the *National Dental Association* will be accepted only from the *State* societies, and that such delegates must be elected by ballot at a regular meeting of the society.

By request of the President.

EMMA EAMES CHASE, Corres. Sec'y,
April, 4, 1898. National Dental Association.

Illinois State Dental Society.

The thirty-fourth annual meeting of the Illinois State Dental Society will be held at Springfield, May 10 to 13, 1898. Dentists practicing in the State of Illinois who are not members of the Society, and dentists of other States, are cordially invited to attend. Hotels and railroads will make the usual reduction. A large attendance is desired and a profitable meeting is anticipated.

A. H. PECK, Secretary,
92 State street, Chicago.

Tri-Union Meeting.

The second tri-union meeting of the Maryland State Dental Association, the Washington City Dental Society and the Virginia State Dental Association will convene in Baltimore, June 2, 3 and 4, in the Dental Department of the Baltimore Medical College, corner Howard and Madison streets. Eminent practitioners from many States will be present to clinic and read papers. The profession is cordially invited.

F. F. DREW, Pres.

W. W. DUNBRACO, D.D.S.,
Cor. Sec'y of the Maryland Ass'n,
1023 Edmondson avenue, Baltimore, Md.

Massachusetts Dental Society.

Annual meeting of the Massachusetts Dental Society convenes at Mechanics' Building, Boston, June 1 and 2.

This convention is expected to be one of the most successful in the history of the Society. Extensive exhibits of material by the various supply houses, and completed operations both in the mouth and in the model by leading dentists and dental laboratories will be a leading feature.

Information to prospective exhibitors upon application to F. S. Belyea, Brookline, Mass., Chairman Committee on Hall and Exhibits.

S. S. STOWELL, President,
Pittsfield, Mass.

E. O. KINSMAN, Secretary,
Cambridge, Mass.

Central Dental Association of Northern New Jersey.

At the annual meeting of the Central Dental Association of Northern New Jersey, held on February 21, the following officers were elected for the ensuing year:

President, F. Edsall Riley, D.D.S., Newark.
Vice-President, C. S. Hardy, D.D.S., Summit.
Secretary, H. S. Sutphen, D.D.S., Newark.
Treasurer, Chas. A. Meeker, D.D.S., Newark.
Executive Committee, Chairman—F. G. Gregory, D.D.S., Newark.
" Fred. C. Barlow, D.D.S., Jersey City.
" C. W. Hoblitzell, D.D.S., Jersey City.
" Wm. H. Pruden, D.D.S., Paterson.
" Wm. E. Truex, D.D.S., Freehold.

New Jersey State Dental Society.

The twenty-eighth annual session of the New Jersey State Dental Society will be held at Asbury Park, commencing July 20, and continuing the 21st and 22d.

The commodious and pleasant "Auditorium" has been secured for the sessions, with unlimited space for clinics and exhibits.

Papers and clinics from many eminent dentists have already been secured.

Preparations are being made for the largest display of electrical exhibits, of appliances for the use of dentistry ever before given; 110 and 500 volt currents being attainable.

The Hotel Columbia adjoining has been secured for headquarters for members and visiting friends; rates will be $2.50 and $3.00 per day.

CHARLES A. MEEKER, D.D.S., Secretary.

H. S. SUTPHEN, D.D.S., Ass't Secretary.

The Louisiana State Dental Society.

The annual meeting of the Louisiana State Dental Society was held at New Orleans on February 23 and 24. Many interesting papers were read and a number of good clinics presented by prominent members of the profession. Committees were appointed to formulate plans for proper legislation, and delegates were appointed to the Omaha Convention. Apropos to the regular routine work of the Society, arrangements were made with the Southern Dental Association to hold a joint meeting with the Louisiana State Dental Society to be held in New Orleans next February, and judging from the present outlook the greatest and most successful meeting of dentists ever held in the South is fully expected. The following officers were elected to serve for the coming term: Doctors J. J. Sarazin, President; J. F. Johnston, First Vice-President; L. D. Archinard, Second Vice-President; Wallace Wood, Jr., Secretary, and C. V. Vignes, Treasurer. Executive Committee: Doctors Jos. Bauer, P. J. Fredrichs, Chas. Mermilliod, M. R. Fisher, C. Ratsburg, Wallace Wood, Jr., Secretary. Board of Dental Examiners: Doctors A. G. Fredrichs, C. V. Vignes, M. R. Fisher, M. F. Comegys, C. B. Johnston.

Please address all communications to Wallace Wood, Jr., Secretary, 625 Canal street, New Orleans, La.

Vermont State Dental Society.

At the twenty-second annual meeting of the Vermont State Dental Society, held at Rutland, March 16 to 18, 1898, the following officers were elected for the ensuing year:

President, Dr. J. A. Robinson, Morrisville.
First Vice-President, Dr. K. L. Cleaves, Montpelier.
Second Vice-President, Dr. Henry Turrill, Rutland.
Recording Secretary, Dr. Thos. Mound, Rutland.
Corresponding Secretary, Dr. Grace L. Bosworth, Rutland.
Treasurer, Dr. W. H. Munsell, Wells River.
State Prosecutor, Dr. G. W. Hoffman, White River Junction.
Executive Committee, Dr. C. W. Steele, Barre.
" Dr. J. E. Taggart, Burlington.
" Dr. J. A. Pearsons, Barton.

Next meeting to be held at Burlington, the third Wednesday in March, 1899.

THOMAS MOUND, Rec. Sec'y.

The Eastern Illinois District Dental Society.

The Eastern Illinois District Dental Society held its twelfth annual meeting at Kankakee, March 15 and 16, and elected the following officers for the ensuing year:

President, I. B. Johnson, Onarga.
Vice-President, J. R. Rayburn, Fairbury.
Secretary, Wm. F. Griffith, Kankakee.
Treasurer, S. A. Campbell, Mattoon.
Superintendent of Clinics, A. M. Hudson, Kankakee.
Executive Committee, W. A. Hooner, F. M. Conkey, A. S. Wattey.

Next meeting will be held at Joliet, the third Tuesday and Wednesday in March, 1889.

WM. F. GRIFFITH, Secretary.